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POWER AND THE ENGINEER

ISSUED WEEKLY BY THE HILL PUBLISHING COMPANY, 505 PEARL STREET, NEW YORK.

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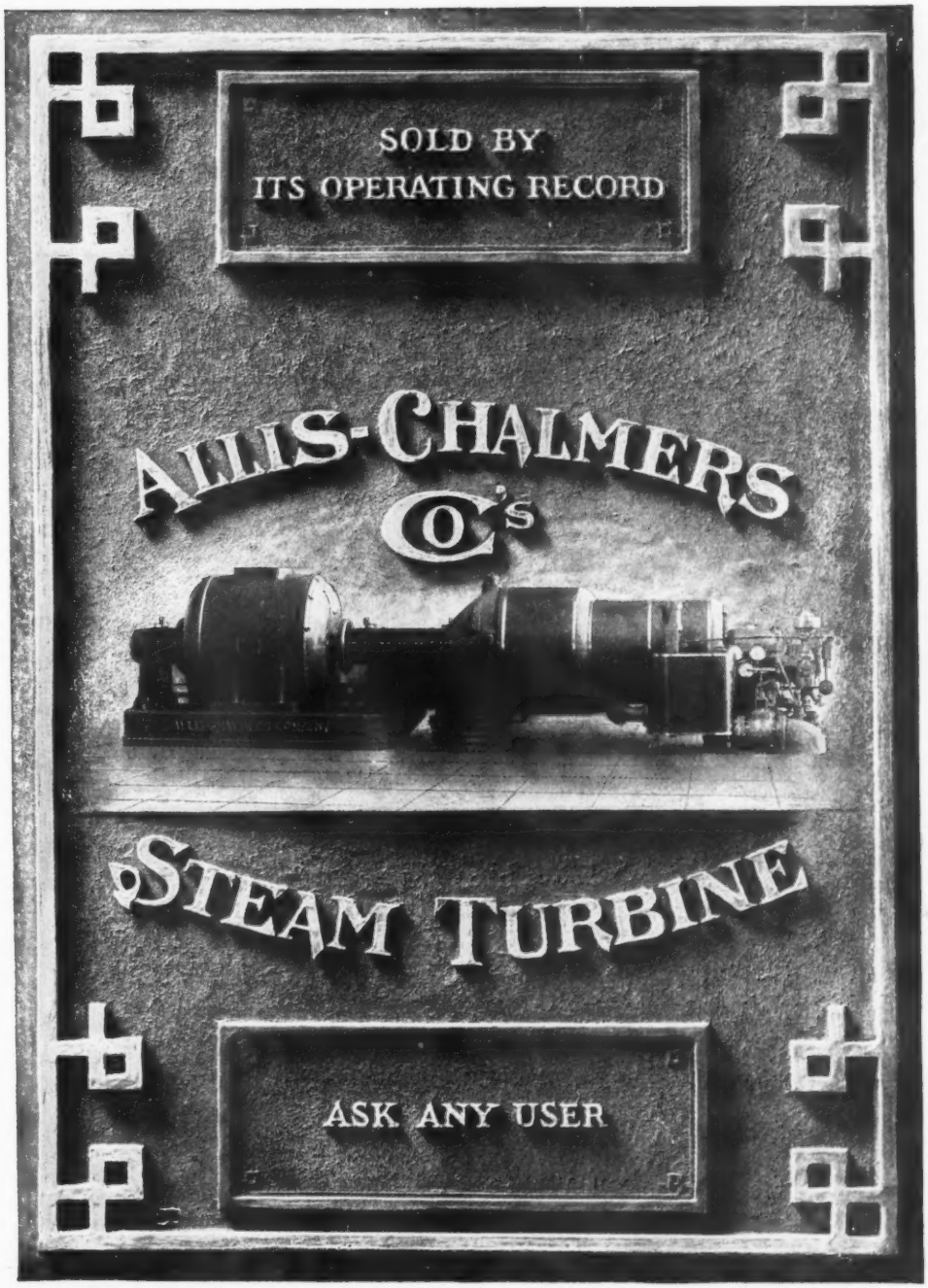

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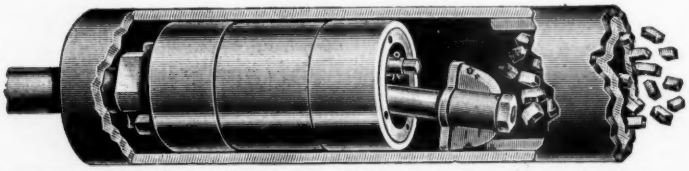

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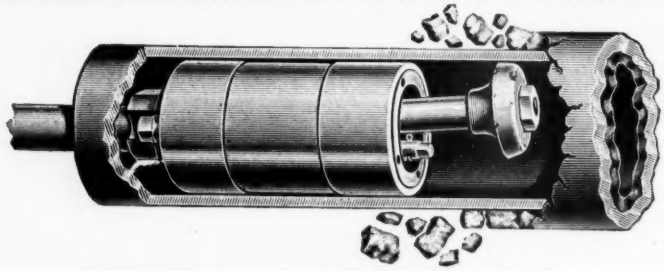

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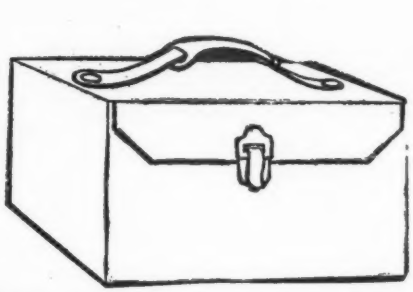

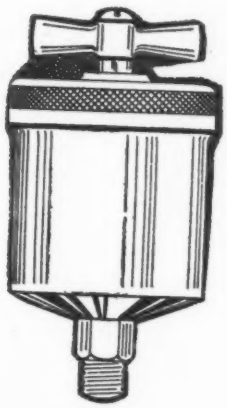

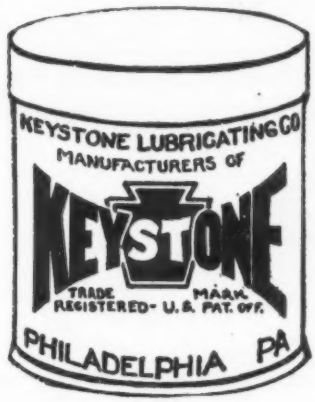

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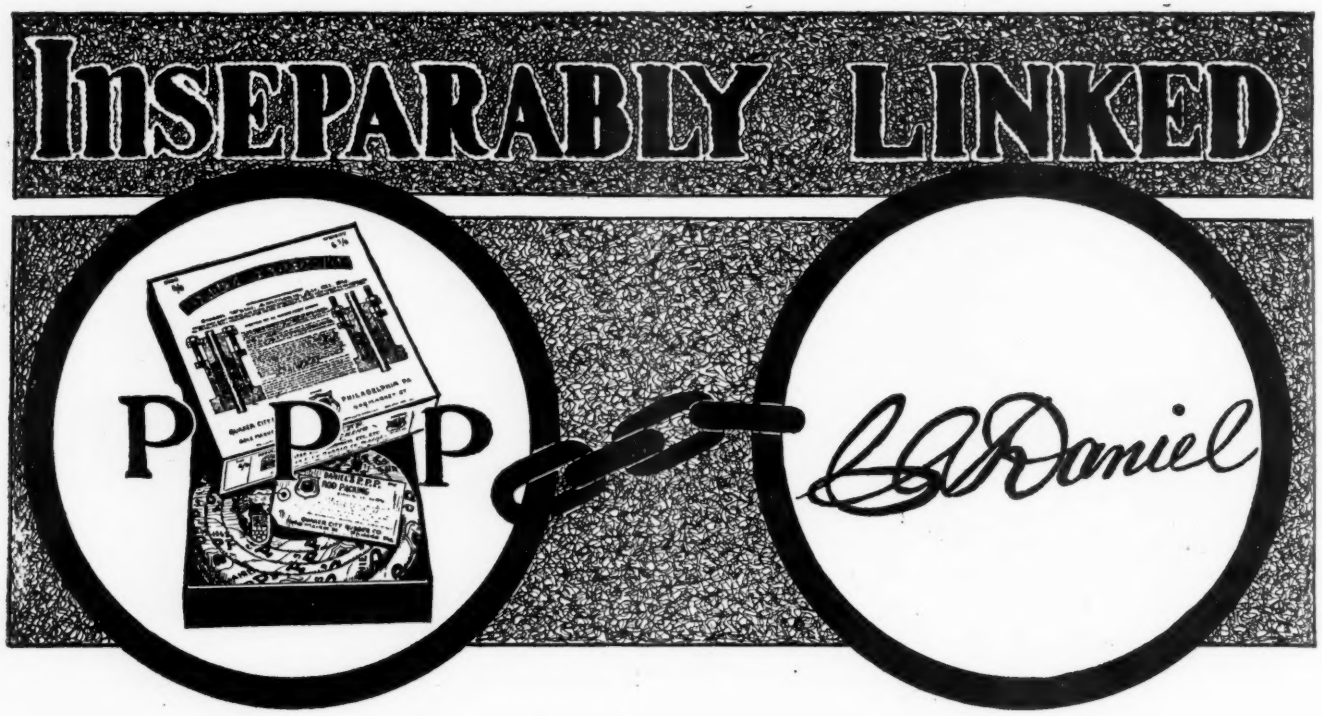

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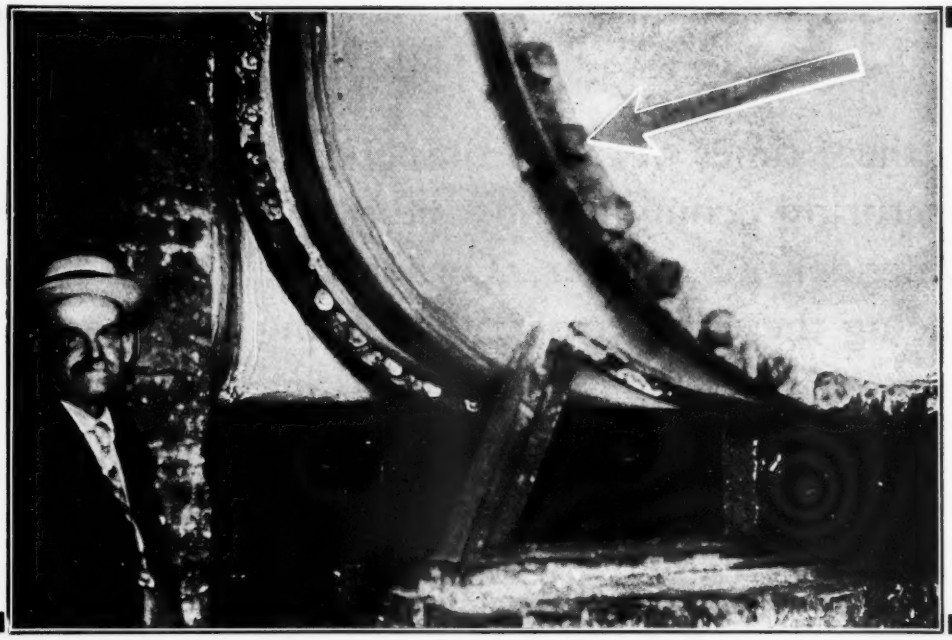

Perhaps you think that SMOOTH-ON ELASTIC CEMENT is only good for the comparatively small repairs, such as tightening screw thread joints, fixing blemishes in castings, etc.

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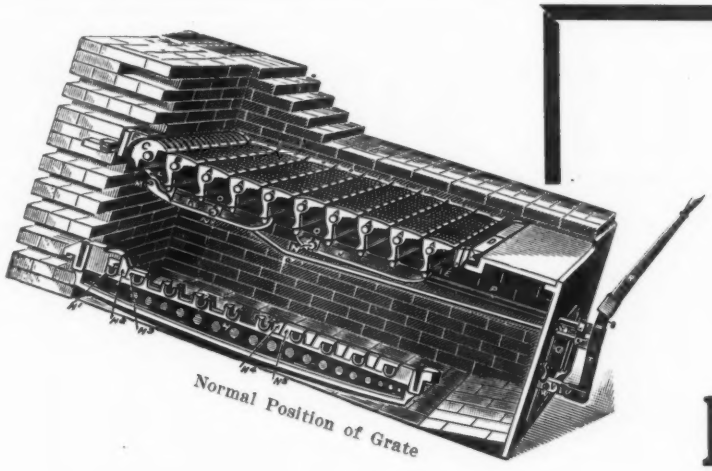
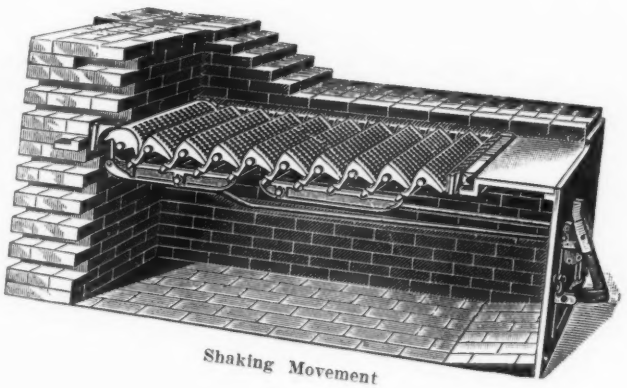
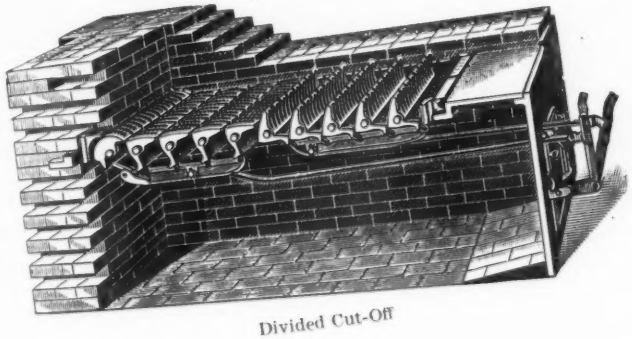


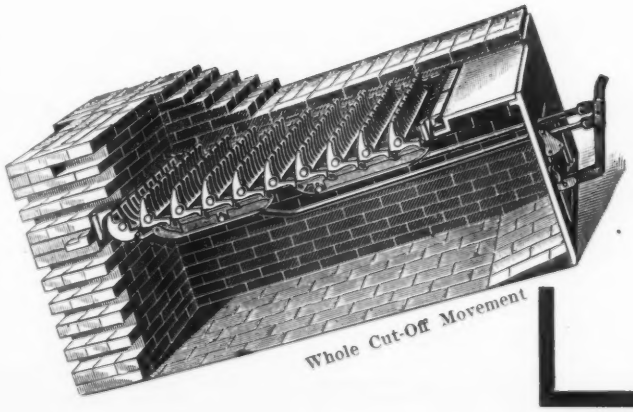
Normal Position of Grate



Shaking Movement



Divided Cut-Off



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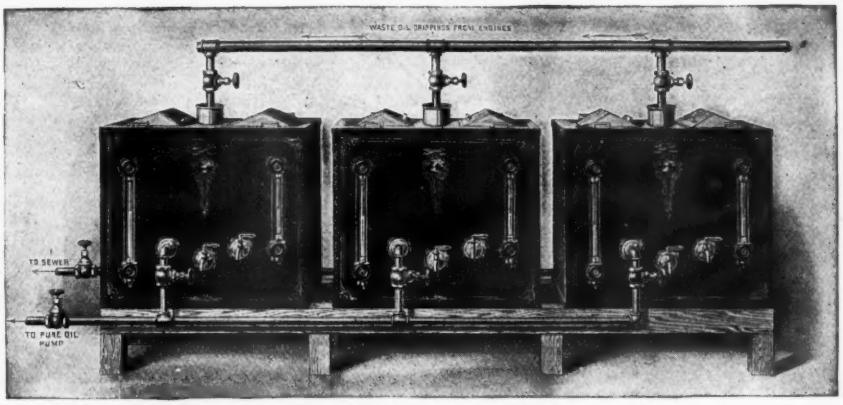

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The illustration herewith shows part of the plant of the Middle States Coal & Coke Co., Olmsted, W. Va., which uses 8 30-inch and 8 24-inch Burt Ventilators. (3rd order.)

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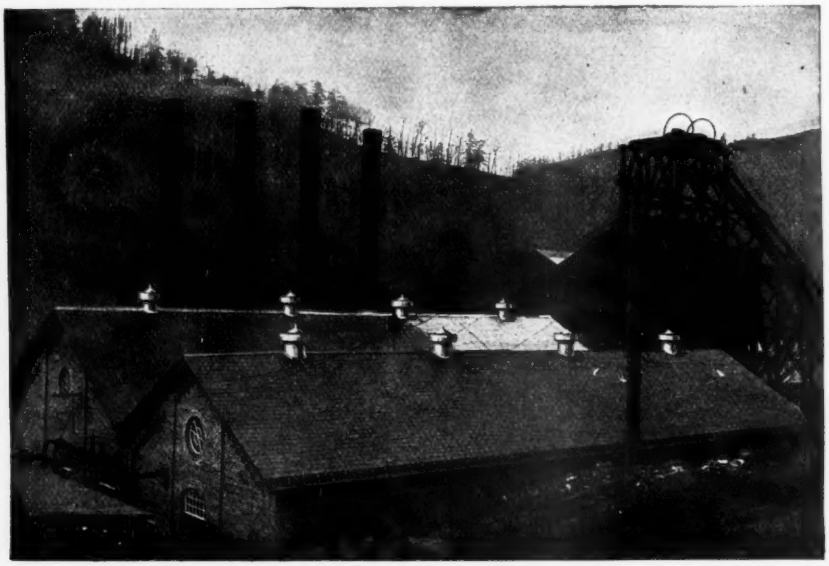

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Prony Brakes for Practical Testing

Different Forms of Friction Brake Described; How They Are Applied and Operated; Essentials of Design Worked Out in a Practical Manner

BY G. EVERETT QUICK

Some form of apparatus for imposing an artificial load on engines, motors, etc., is well-nigh indispensable to builders of such machinery and will be found of great advantage to users also. In order to be of the greatest value, the apparatus must be such that the load which it imposes on the engine or motor can be accurately measured and completely controlled. Such apparatus is the absorption dynamometer, the simplest form of which is the friction brake.

For example, it is generally considered advisable to make the efficiency test of a water wheel after it has been installed, even though originally tested by the manufacturers. There are numerous details in the setting of the wheels which may alter the efficiency, and by using an inexpensive friction brake and a current meter, a test can be readily made by means of which the trouble may be located and corrected. A satisfactory brake can be built by the engineer in charge without difficulty if the instructions herein given are followed.

Except with very small powers, radiation and convection due to stray air currents will not be sufficient to dissipate the heat as rapidly as it is generated, and special provision for doing this must be made. This is most satisfactorily accomplished by a stream of cooling water circulating through an inclosed or partly inclosed jacket; by carefully regulating the supply the brake can be kept near the temperature at which it gives its best results. It is even best to cool the brakes used on small units in order to insure a reasonable degree of constancy in the load. In the common form of friction brake, where the brake arm is adjustably clamped to the brake wheel, a temperature change results in a contraction or expansion of the metal wheel and the adjusting screws must therefore be continually changed to keep the pressure between the friction members, and consequently the brake load approximately constant.

The best known type of friction brake is the widely used and much abused prony brake, and in spite of its inherently bad features for certain work, its simplicity, cheapness, and applicability to nearly all kinds of motor of small and medium capacity enable it to maintain a place for itself in industrial testing. This brake is built in many different forms. More uniformity is noticed in the design of the brake wheel than in any other part. It is usually of cast iron, practically free from sand holes and with deep internal flanges at the rim to retain the cooling water. In the small sizes one side of the wheel is often completely inclosed, as shown in Fig. 1, while those of greater capacity have spokes so designed as to allow the water to circulate over the entire inner face of the rim between the flanges, as in Fig. 2. Frequently shallow external flanges are cast on the sides of the rim to act as guides for the brake arm, but usually these guides are fast-

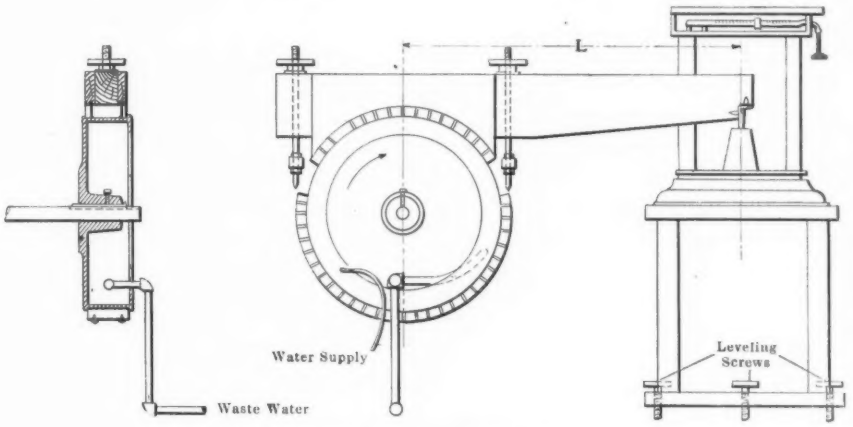


FIG. 1. ONE FORM OF PRONY BRAKE

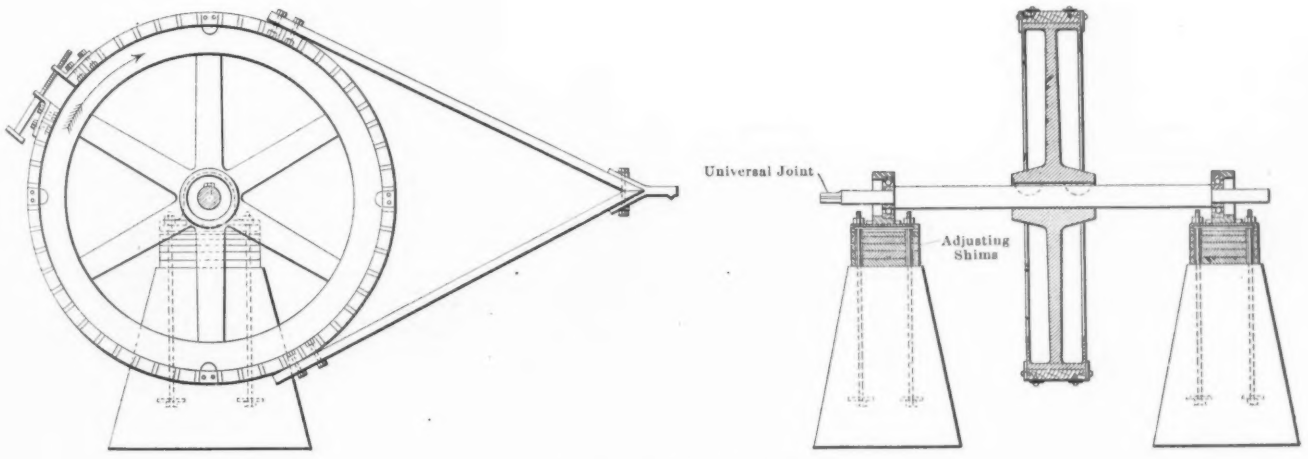


FIG. 2. PRONY BRAKE OF LARGE CAPACITY

ened to the brake arm itself. The outer surface should have an unusually smooth finish and must be perfectly balanced and concentric with the axis of the shaft on which the wheel is to be mounted, in order to reduce to a minimum objectionable vibrations due to the rotation of an unbalanced mass. Where possible, the final cut ought to be made with the wheel mounted on its own shaft, the latter revolving in its bearings in the same relative position in which it is to be used. Usually in experimental work, and often in commercial testing, this wheel is securely keyed to a separate jack shaft made as short as possible and supported at both ends on rigid pedestals, with substantial bearings, preferably of the annular ball type and allowing only about 1/32 inch end play of the shaft. In fact, as all who have used the prony brake are well aware, one of the chief disadvantages in its use is the uncertainty of the scale readings due to the tendency of the brake arm to vibrate excessively. These vibrations come from two sources, namely, failure of the wheel to run perfectly true under load (which may be due to springing of the shaft, unbalancing of the wheel, or a lack of rigidity of the bearing supports), and a chattering produced by the lack of a smooth engagement of the friction members. The dynamometer shaft is driven by the motor shaft through a universal joint which will not be a source of error if the two shafts are properly alined.

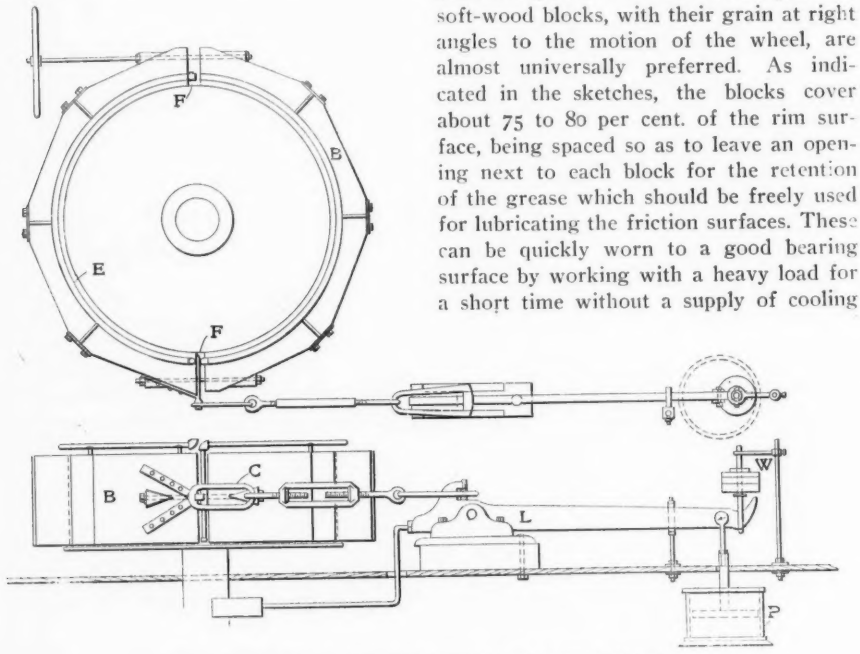


FIG. 3. PRONY BRAKE FOR VERTICAL-SHAFT MOTORS

The actual construction of the brake differs somewhat in detail according to the ideas of the designer and the requirements of the test for which it is designed. Although the spring balance was formerly used to some extent to indicate the pull at the end of the brake arm, its unreliability has caused it to be displaced by the beam balance and the suspension of a known weight. The latter is the most convenient means in commercial use. The smoothness of operation and accuracy obtained with such a brake depend somewhat on the material and condition of the frictional contact. Babbitt metal, bronze, soft and hard wood, leather and cork have been used, but in commercial practice, soft-wood blocks, with their grain at right angles to the motion of the wheel, are almost universally preferred. As indicated in the sketches, the blocks cover about 75 to 80 per cent. of the rim surface, being spaced so as to leave an opening next to each block for the retention of the grease which should be freely used for lubricating the friction surfaces. These can be quickly worn to a good bearing surface by working with a heavy load for a short time without a supply of cooling water. The excessive heat will slightly char the surface of the wood and wear it to a true face verge rapidly. Dry strips of leather which have no indication of being sticky or gummy, and for small powers flat pieces of cork with hardwood or metal retainers have been successfully used in reducing the vibrations.

Although oil or grease is ordinarily used for lubrication, some engineers use a jet of water or strong soap suds directed on the external surface of the wheel in place of the internal cooling water. Unless the brake is at least partially inclosed the liquid thrown from the revolving wheel makes surrounding objects look like a "kitchen floor on scrub day." Cooling in this way is not as uniform and with pure water the lubrication is so poor that the vibrations at the brake arm are excessive. With internal water cooling, the best results are obtained when the stream of water is regulated to keep the temperature a little below boiling. At the temperatures which are likely to prevail, a circulation of one pound of water per minute will dissipate heat equivalent to about two to three horsepower. Although not confined within definite limits, the depth of water in the annular trough is generally about 5/16 inch for every 25 horsepower absorbed, this value being slightly high for low speeds and a little low for high speeds. The scoop and outlet pipe should be of ample size and the former shaped to cut the water with a sharp edge nearly parallel to the direction of motion.

Considerable leeway is permissible in determining the diameter of the brake wheel, the choice being governed somewhat by the rim speed. If less than 1000 feet per minute the action of the cooling water is apt to be erratic, its centrifugal force not being great enough to spread it evenly in the trough. If the rim speed exceeds 5000 feet per minute, trouble is experienced with excessive vibrations. Average practice ranges between 1500 and 4000 feet per minute, the lower value for low-speed motors and the higher for high-speed motors.

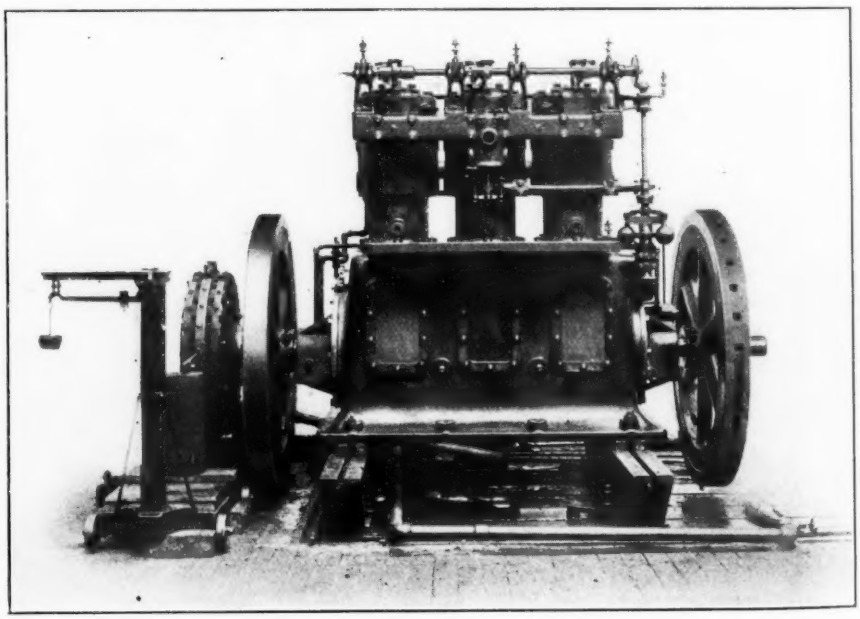


FIG. 4. PRONY BRAKE ON SHAFT OF WESTINGHOUSE GAS ENGINE

Of the many different forms of brake arm, Figs. 1 and 2 show those in most

common use. The former has a straight lever adjusted to a horizontal position by a level or otherwise, and is commonly used where a fairly low horsepower is combined with a high speed, requiring a brake wheel of small diameter, such as automobile engines, etc. As the effective length of this lever as used in the calculation for horsepower is the horizontal distance from the center of the brake wheel to the point of contact on the platform scales, it will be readily seen that the greater the diameter of the brake wheel or the shorter the brake arm, the greater will be any inaccuracy due to a variation from its true horizontal position. This error, however, is negligible if care is taken in leveling the arm. Both forms have a friction surface of soft-pine blocks fastened in position by flexible steel strips, except the upper row of blocks in Fig. 2, which are fastened to the side pieces of the arm. With very small brakes, blocks may be omitted altogether and the arm and strap cut out of solid wood to fit the wheel.

When the vibrations are unusually severe an oil or water dashpot near the end of the lever arm, as P, in Fig. 3, is often used.

Another important detail in design that must be considered is the proper contact surface area. If the surface in contact with the pulley is too large, the load on the brake is not sufficiently sensitive to a variation in the adjusting screw and regulation is unsatisfactory. With too small a contact area, the regulation is over-sensitive and sudden shocks and vibrations are transmitted to the scale beam. Professor Carpenter, in "Experimental Engineering," states that the value of

$$K = \frac{W \times V}{H.P.}$$

must not exceed 500 to 1000, while 400 to 500 gives the best results. In this formula

W = Width in inches,
V = Rim speed in feet per minute,
$H.P.$ = Horsepower to be absorbed.

Flather, in his "Dynamometers," gives K an average value of 400 for the ordinary noncompensating water-cooled brake, and 750 for the compensating type.

The power absorbed by a friction brake is measured by the resistance it offers to the rotating shaft. This equals the product of the force, W, which opposes the rotation of the brake lever at the distance L from the center of the brake wheel, multiplied by the linear speed of this point of resistance if it rotated with the brake wheel. From this it is evident that the diameter of the brake wheel, or the coefficient of friction do not enter into the calculations for horsepower. This will be made clearer, perhaps, by the following analysis:

Let

W = Net pull in pounds at the end of the brake arm,
w = Net pull in pounds at the rim of the brake wheel,
L = Effective length of the arm, from the center of the brake wheel to the point where the pull is measured,
r = Radius of the brake wheel, to the friction surface,
N = Number of revolutions per minute, by the wheel.

The velocity V of the friction surface of the wheel in feet per minute will be

$$3.1416 \times 2\,r \times N$$

and the foot-pounds per minute absorbed by the friction will be

$$3.1416 \times 2\,r \times N \times w =$$

foot-pounds per minute.

Now the pull w at the wheel rim is

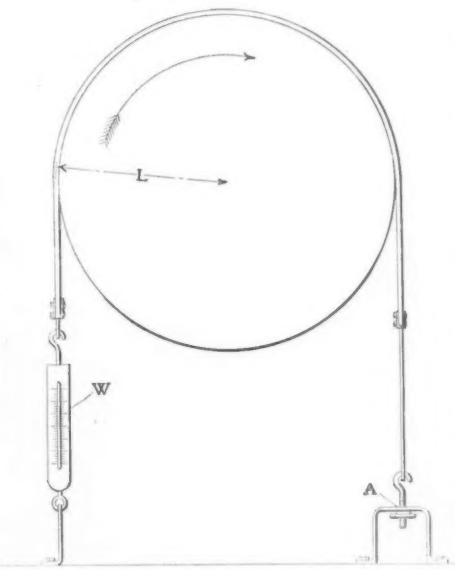


FIG. 5. STRAP BRAKE

equal to the pull W at the end of the arm multiplied by the ratio of arm length L to wheel radius r; thus:

$$w = W \times \frac{L}{r}.$$

Substituting this equivalent in the foot-pounds formula: Foot-pounds per minute =

$$3.1416 \times 2\,r \times N \times W \times \frac{L}{r},$$

and as the two r's cancel out foot-pounds per minute =

$$6.2832 \times N \times W \times L.$$

$$H.P. = \frac{6.2832\ N\ W\ L}{33{,}000},$$

which may be also written

$$H.P. = k\ N\ W,$$

in which

$$k = 0.0001904 \times L.$$

The horsepower calculations are greatly facilitated if a value for L is chosen which will make k a decimal with only one significant figure. Thus, where

$L = 5.252$ feet, or $63\frac{1}{8}$ inches, $k = 0.001$,
$L = 3.676$ feet, or $44\frac{1}{8}$ inches, $k = 0.0007$,
$L = 2.626$ feet, or $31\frac{9}{16}$ inches, $k = 0.0005$.

The $63\frac{1}{8}$-inch lever arm is ordinarily used for horsepowers between 100 and 250 at moderate speeds, while, with very low speeds or greater horsepowers the arm should be correspondingly longer. At the lower horsepowers the speeds vary between wider limits, and this, as well as the horsepower, governs the length of the arm, which should decrease with the former and increase with the latter. The $31\frac{9}{16}$-inch arm has been used with good results for horsepowers between 5 and 40 at speeds under 300 revolutions per minute, and up to 75 horsepower at speeds above this. Needless to say, these directions are merely approximate, and are only intended to afford a general guide to the selection of an arm length which will bring W within reasonable limits for reading.

The pressure of the brake arm on the scales is greater than the value W entering into the calculations by an amount equivalent to the unbalanced weight of the arm. Sometimes this is counterbalanced by suspending a weight at the short end of the arm, but more often by weighing the unbalanced pressure and making a zero correction on the scales known as the brake constant or "tare." One way to ascertain this value is to loosen the brake so that it will hang freely from a knife edge inserted between the top of the brake and the rim of the wheel and at a point vertically above the center of the wheel.

Motors having a vertical shaft cannot make use of the prony brake in its usual form. Fig. 3 shows how the Holyoke Water Power Company, of Holyoke, Mass., transfers the horizontal torque of the brake B to a vertical plane by means of the link C and bell-crank lever L, and balances the pull by an adjustable weight W on its end. The brake strap consists of hard-wood blocks with spiral grooves and is kept in place by the lower external flange on the rim of the pulley. Cooling water is supplied to the external rim of the wheel through pipes E and sprayed at F, although it is often necessary to substitute strong soap suds to prevent severe vibrations. A shield of canvas intercepts the spraying liquid thrown from the surface of the wheel, and it is collected into the wheel pit below. It is seldom possible to use this brake without the dashpot P to check the vibrations.

The principal disadvantage in the use of the prony brake in extended commercial

testing are the uncertainty incident to the vibrations, which are so difficult to eliminate, and the constant attention required to keep the load constant. These become more serious with an increase in the number of testing stands in continual use, as in a factory which turns out a large number of small units, since the labor item will be a large percentage of the cost of testing. The advantages are the low initial cost of the equipment, its adaptability to different types of motors, and its simplicity.

Fig. 4 shows a prony brake fitted to the crank shaft of a three-cylinder Westinghouse gas engine ready for a load test.

Strap and Rope Brakes

Other forms of friction brake having essentially the same style brake wheel as the prony brake, but provided with a flexible band or rope in place of the brake blocks and extension arm, are used to a limited extent. The strap brake, illustrated in Fig. 5, is used for very small powers. The prony-brake formula for calculating power is used, W being read on the spring balance, and L being equal to the radius of the brake wheel plus half the thickness of the brake strap. The material of the strap is usually leather free from stickiness, but it may also be prepared canvas, or other material. The load adjustment is at A.

With a typical rope brake, its chief advantage lies in the ease with which it can be applied to the flywheels of certain motors without any provision for water cooling. A very steady load may be obtained with a wheel-rim speed as high as the requirements of safety will allow in a flywheel, reaching 8000 to 9000 feet per minute. This is an advantage over the prony brake, but it will be readily seen that for the same horsepower the higher speeds demand flywheels of smaller diameter than with the lower speeds, and consequently the value L, which depends on the radius of the wheel, is less, while the weight and strain on the rope and balance are correspondingly greater. At low speeds and horsepowers the heat-radiating surface per horsepower is large enough to make water cooling unnecessary. With wheel rims of greater width, the number of turns of rope in parallel may be increased by using a suitable equalizing device and this reduces the pressure of any one rope on the wheel. This will allow a greater horsepower to be absorbed before the rope begins to char at its point of maximum pressure. In general, water cooling will be found advisable if the revolutions per minute times the horsepower exceeds about 15,000, unless a multiplicity of ropes, balances, or a complicated equalizing device is used. Ropes as large as can be conveniently handled, say from 1 inch to 1½ inches, usually give better and longer service than smaller ones. Little lubrication is needed, but occasionally smearing the rope with grease has been known to give good results.

Although the rope tension is usually obtained by suspending a weight from the free end and read by a spring balance at the upper end, the adaptability of the arrangement represented in Fig. 6 will be readily appreciated. The difference between the tensions at the two ends of the rope measured the effective pull and is recorded by scales on the platform of which the standard J is placed. To the cross arm at the top of this standard are fastened the hook bolts over which the bights of the ropes are looped; the ends of the ropes are clamped to a cross bar which equalizes the strains when a weight is suspended at its center. In absorbing small loads at low speed, regulation is obtained by providing the hooks H with adjusting screws on their shanks, but with higher speeds, necessitating a smaller pulley, the writer found that the strain on these adjusting screws becomes so great that sensitive regulation can only be obtained by making the pull on the free ends of the rope adjustable. This was provided for by replacing the suspended weight with a rope R, passing under pulleys in the base of the standard and fastened to a finely threaded adjusting screw A conveniently mounted in the other end of the cross arm. Excellent regulation was obtained in this way.

The standard and scales must be placed so that the pull is vertical and the scales platform level. The brake constant or zero correction equals the weight of the standard and its fittings plus the weight of a section of the rope. To find its value, weigh it with the adjusting screw A loosened up until the ropes hang free from tension, but in their normal position.

The same formula is used for calculation of power as with the prony brake, but L is equal to the radius of the wheel plus half the diameter of the rope. Owing to the wear and stretch of the rope, the distance between the center line of tension of the rope and the surface of the brake wheel is uncertain, but is taken as the radius of the rope. With high-speed motors and small wheels the error will probably not exceed 1 per cent. With low-speed motors it is negligible.

The chief advantages of the rope brake lie in its low first cost and ready adaptability to testing certain small- and medium-sized units, giving it a decided advantage even over the prony brake within the specified limits. It, of course, requires the constant attention of the tester and a frequent renewal of ropes is necessary.

Numerous self-adjusting friction brakes designed to keep the load constant automatically by changing the pressure of the brake strap, have been invented; but with one or two exceptions the added complication in the hands of an inexpert mechanic does not seem to warrant general adoption in commercial work.

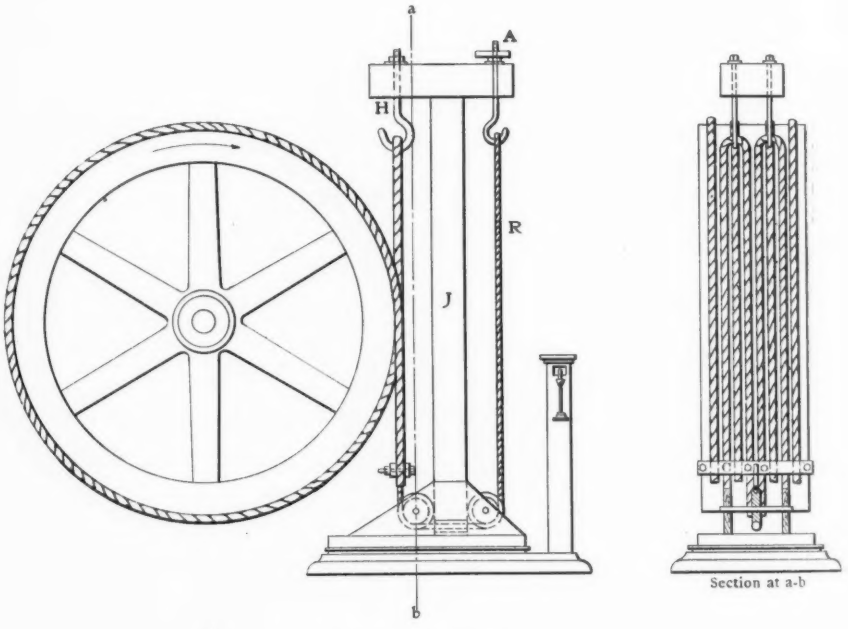


FIG. 6. ROPE BRAKE

The slide rule was invented nearly 300 years ago. The *Zeitschrift für Vermessungswesen* calls attention to the fact that Gunter, shortly after his bringing out the trigonometric logarithm tables in 1620, placed logarithmic scales on wooden rules, and used a pair of dividers to add or subtract the logarithms. In 1627 these logarithmic scales were drawn by Wingate on two separate wooden rules, sliding against each other, so as to render the use of dividers unnecessary, and in 1657 Partridge brought out the slide rule, more or less in its present form.

The Autotransformer

By R. H. Fenkhausen

When a transformer is desired for a small ratio of transformation, the greatest satisfaction and efficiency are obtainable by the use of an autotransformer. The autotransformer is known by various other names, depending on the service to which it is applied, such as "compensator," "balancing coil," "reactive coil," "economy coil" and, in motor work, "autostarter."

In all of these forms its construction is identical in principle, and follows closely that of the ordinary transformer, with the exception that one winding serves for both primary and secondary. Autotransformers may be of either the core or shell type, but they are usually made in the latter form, which is illustrated by Fig. 1. The autotransformer not only operates at a better efficiency than the two-winding type, but costs less to build, because of the smaller amount of material required in its construction. In a 2 to 1 autotransformer the saving in material is about 35 per cent. of copper and 20 per cent. of iron. The saving in material varies with the ratio, being greatest for a 1 to 1 ratio and only about 1 per cent. for a ratio of 100 to 1. One disadvantage of the autotransformer lies in the fact that the high- and low-voltage terminals are at all times metallically connected and the insulation of the low-voltage circuit is at all times subjected to the stress due to the high voltage.

Among the principal applications of the autotransformer are motor starting and speed regulation, low-ratio voltage transformation and the balancing of voltages on multi-wire systems. In the latter service its capacity is determined by the maximum unbalanced load on the system; for a three-wire system with 80 kilowatts on one side and 100 kilowatts on the other, a 20-kilowatt autotransformer would be required. Fig. 2 illustrates this application and the conditions just stated. The maximum capacity necessary in the worst possible state of unbalance would be 50 per cent. of the total connected load; this could happen only if all the lamps on one side of the system were lighted and all on the other side were out, but as this condition would hardly ever occur in practice, an autotransformer having a capacity of 25 per cent. of the total connected load is usually installed.

Another useful application of the autotransformer is to provide a neutral point for grounding a two-wire system, as indicated in Fig. 3. When applied in this manner to a 500-volt system, the maximum difference of potential between the ground and any point on the circuit cannot exceed 250 volts; consequently the stress on the insulation of all connected apparatus is lessened and the possibility of a dangerous shock is obviated.

It is often desirable to provide a 110-220-volt three-wire system when the only available supply is 220 volts. By using an autotransformer to supply the neutral point and carry the unbalanced load this is easily accomplished; Fig. 2 indicates such an arrangement.

The high efficiency of the new metallic-filament lamps, especially the tungsten, makes their use desirable, but owing to the fact that they are not at present obtainable commercially for higher potentials than 125 volts, the customers of small stations are, as a rule, unable to make use of them, the prevailing voltage of stations in small towns and suburban districts being 220. The low first cost and high efficiency of the autotransformer make it a practical remedy for this condition; the central station can install them at various points on the system and from each main wire and the neutral so obtained supply 110 volts. The residences must be about evenly divided between the two sides of the system in order to obtain so nearly a balance that the autotransformer capacity required will be small. This gives practically all the advantages

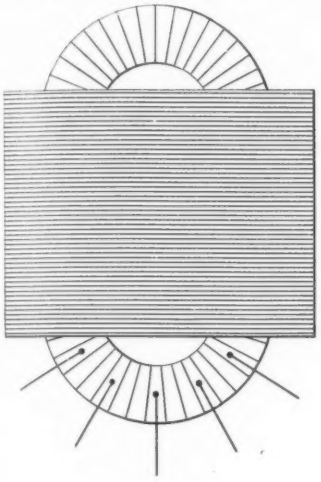


FIG. 1

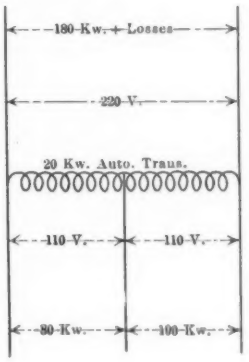


FIG. 2

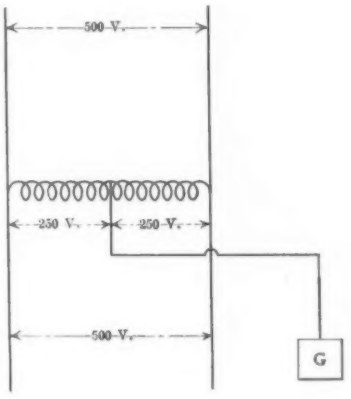


FIG. 3

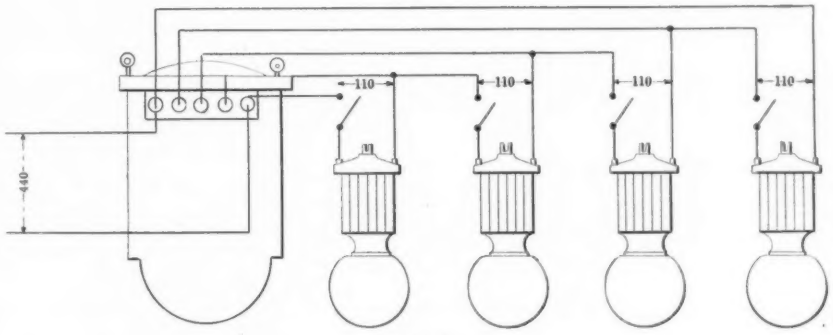
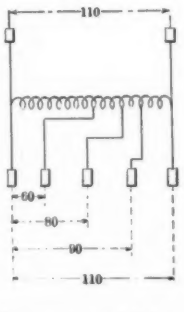
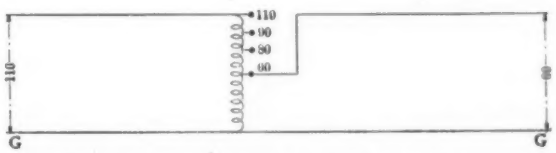


FIG. 4





Wire G must always be Connected to Grounded Side of System or Both Systems if Each is Grounded.

FIG. 5

of a two-dynamo 110+ 110-volt system without altering the original generating or distributing equipment. This, however, applies only to plants which generate 220 volts and use no transformers; when transformers are used 110 volts may be obtained by simply changing the secondary connections, as described in a previous article.

transformer is generally used to reduce the line voltage to the low voltage necessary for the motors, lights and control circuits.

An autotransformer is particularly useful in testing, as with it the supply voltage may, by suitable taps, be stepped up or down to any desired values within reason.

time ago. The engine was a 26x48 twin, running at 80 revolutions, with a wheel 18 or 20 feet in diameter with 30 grooves for 2-inch ropes. The wheel was double-armed, and every spoke broke off close to the limb. The lower screw in the cut-off cam had worked loose and was caught as shown by the sharp edge of the steel toe on the back arm of the pickup hook.

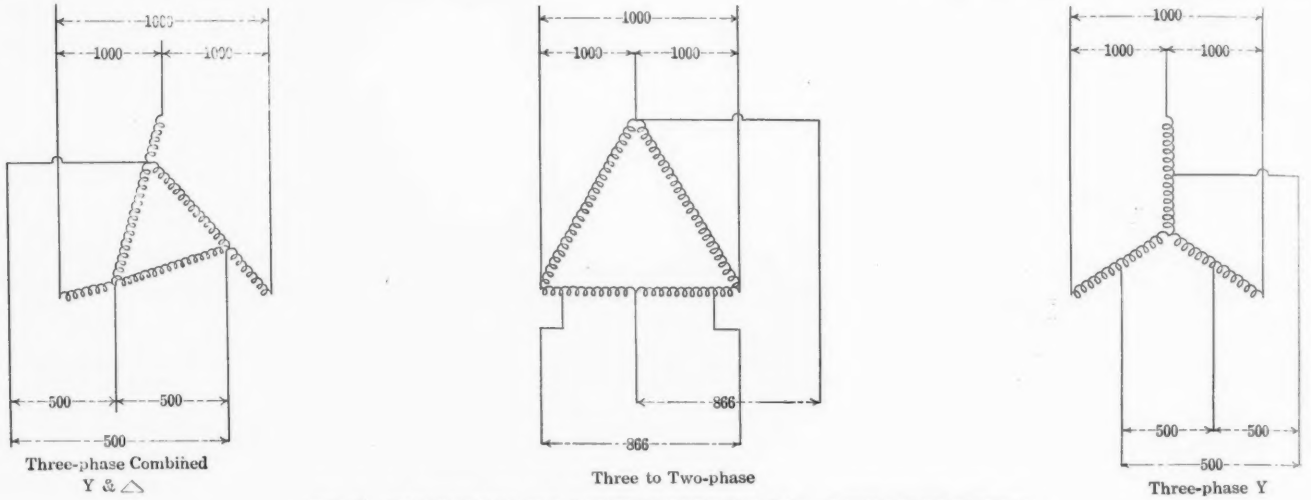


FIG. 6. CONNECTIONS FOR AUTOTRANSFORMERS ON A THREE-PHASE CIRCUIT

If a central-station company will not supply 110 volts, the consumer may profitably install a small autotransformer of his own between his load and his meter; the small losses of the transformer and the interest on the investment will be saved several times over by the higher efficiency of the tungsten lamps, and most of the losses may be avoided if the autotransformer is switched off when the lamps are not needed.

It is often desirable to operate two 110-volt arc lamps on a 220-volt circuit or four on a 440-volt circuit and still be able to control them separately. Fig. 4 shows how the latter may be accomplished by a five-point autotransformer.

Fig. 5 is a diagram of a special autotransformer constructed for use in a shipyard where the supply voltage was 110, but where it was often necessary to supply current to the switchboards of vessels undergoing repairs, and equipped with electric-light plants of 60, 80 or 90 volts. In using such an arrangement to supply ships wired for a ground return system, and where the supply circuit is also grounded on the secondary, care must be taken to get both grounds connected to the line which passes the transformer without being cut (*G*, in Fig. 5), otherwise the full 110 volts will be on the ship's lamps and burn them out; there will also be great liability of destroying the autotransformer because part of its winding will be short-circuited. Even when no ground exists on the ship-wiring system, this rule should be observed; otherwise the insulation of the ship wiring will be subjected to 110 volts to ground and may break down.

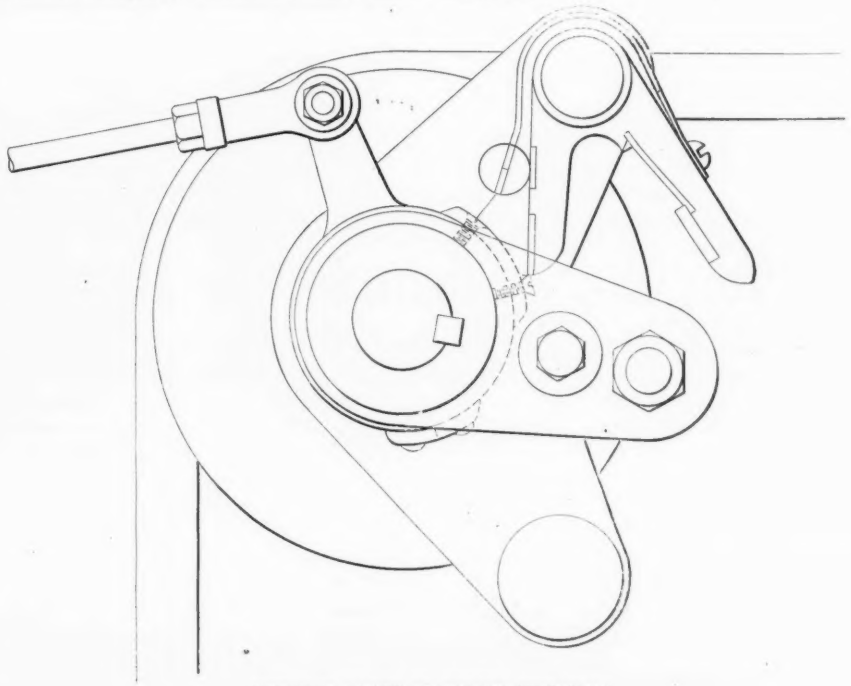
In single-phase railway work the auto-

Fig. 6 shows some connections for autotransformers on a three-phase circuit. The diagrams give the voltages of the main circuit and those derived from the autotransformers with the connections indicated; these may be varied, of course, to obtain any secondary voltage desired.

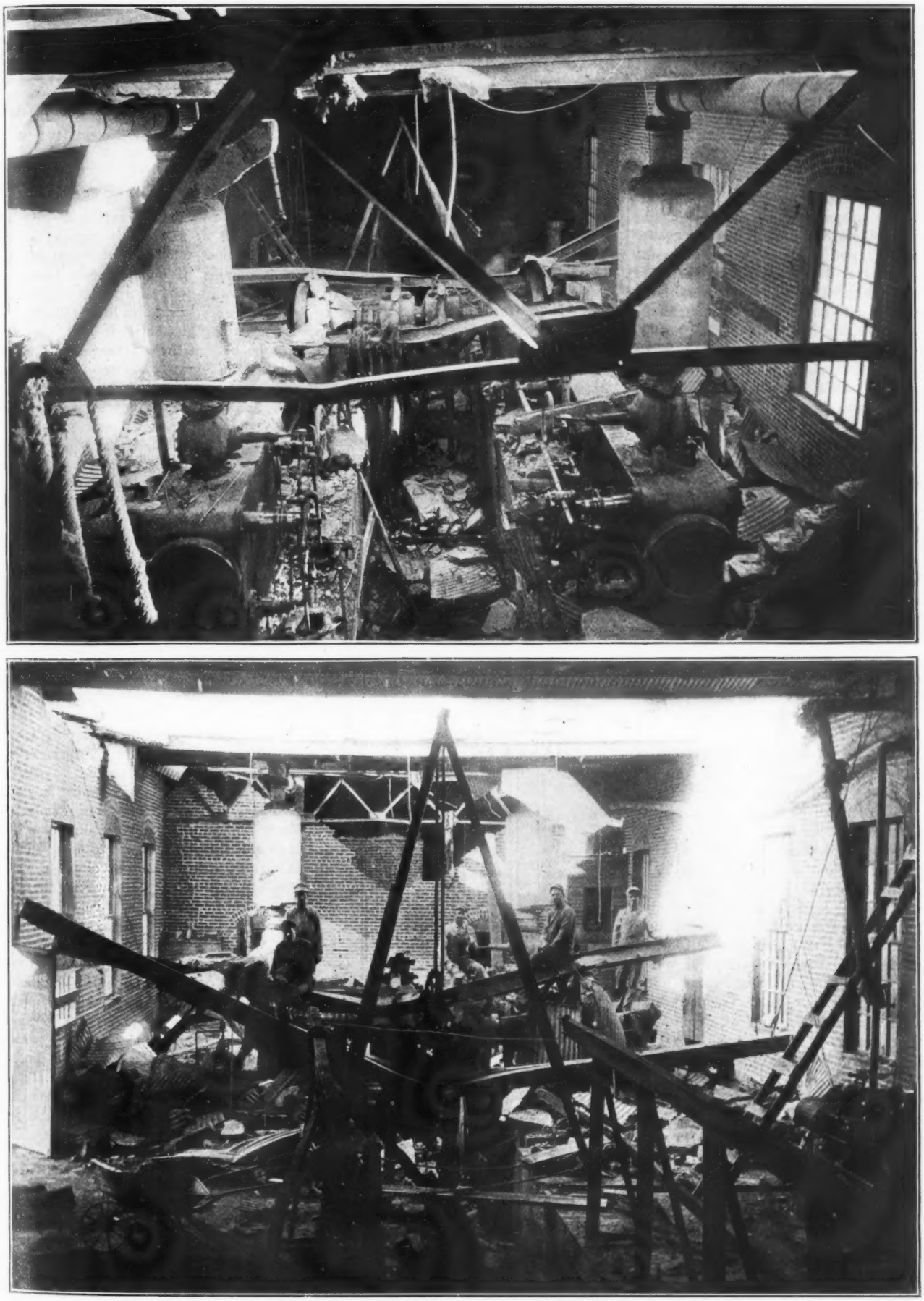
Cause of Engine Runaway

The accompanying drawing shows the cause of a disastrous runaway of an engine at the works of the Indian Portland Cement Company, Neodesha, Kan., some

The screw broke off down in the plate, and the plate was carried away, the other screw shearing off. This allowed the steam hook to hang onto the valve crank continuously, released it from the control of the governor, prevented the engine from cutting off, and the steam, carried for the full stroke, speeded the engine up above the breaking point of the flywheel before the throttle could be closed. After the wreck the cutoff cam was found to be off from the other end of the same cylinder, and three of the safety cams were missing, two having evidently been off for some time.



SHOWING CAUSE OF ENGINE RUNAWAY



RESULTS OF ENGINE RUNAWAY AT THE INDIAN PORTLAND CEMENT COMPANY'S PLANT

Methods of Guarding Against Lightning

Descriptions of Four Types of Arrester Which Contain Novel Features; Use of Wires Strung Parallel to the Power Wires

BY W. T. RYAN

Lightning arresters depending on the action of moving parts for their operation have not generally been successful. The fact that they have moving parts is a disadvantage. One of these forms, however, and only one, has been commercially successful; this is shown in Fig. 1. The discharge enters the arrester by the binding post *A*, thence passing across the resistance *B* which is in parallel with the coil *F*, thence through the flexible card *C* to the guide rod *D* and the armature *E*, which ordinarily is in contact with and rests on the carbon *H*; thence across the air gap to the lower carbon *J* and into the ground.

When the discharge passes across the high resistance *B*, a portion of the current is shunted through the coil *F*, which is thereby energized, drawing the iron armature *E* upward and instantly forming an arc inside of the tube *G*, between the armature *E* and the lower carbon *J*. This tube being nearly air-tight, the oxygen is quickly consumed, the current ceases, and the coil loses its power, allowing the armature to fall back again into place.

The loose coherer type, Fig. 2, consists of a glass tube mounted on a suitable support and filled with a number of fine particles of oxidized metal which practically open the circuit for ordinary voltages because of their bad electrical contact with one another and yet pass high-tension discharges. The resistance of the many contacts is depended upon to suppress the short-circuit following a discharge. A tube 18 inches long filled with such metallic particles is said to be suitable for lines up to 2200 volts. For higher voltages more tubes are used, and as an extra precaution against a continuation of the arc they are connected in series with an adjustable air gap.

The fixed coherer type of lightning arrester is illustrated in Fig. 3. This arrester is based on the proposition that a disruptive discharge will jump over a nonconducting surface much more readily than through an air space of equal length. If one should take a piece of rough glass or unpolished marble and make a pencil mark across it, this would be a fairly good lightning arrester of the type mentioned. The commercial arrester consists of two lignum-vitae blocks 3x3½ inches and 1 inch thick, with two 1-inch brass electrodes *A* and *B* inserted in the top and bottom blocks flush with the surface, giving a distance of 1 inch between the terminals. There are nine grooves 1/16 x 1/32 inch between the electrodes *A* and *B*, which are filled with small grains of hard carbon. The discharge passes in the form of innumerable microscopic sparks between the carbon grains, and no arc is developed.

The Horn Arrester

In the horn or diverging air-gap arrester in its simplest form, a single air gap between two horn-shaped terminals

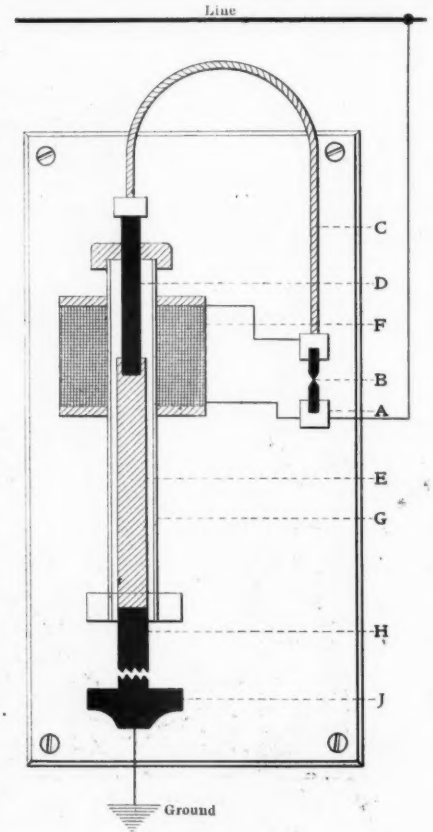


FIG. 1

is used. These are so arranged that the magnetic action of the arc, together with the tendency of the heated vapors to rise, forces the arc toward the spreading tips, thereby increasing the length of the arc until the generator voltage can no longer maintain it. This form of arrester has several defects. On low voltages the smallest part of the air-gap is so small as to make it difficult to keep the distance constant. Dirt, bugs and bending of the terminals will change the length of the gap. On high voltages the potential difference necessary to break across an air-gap long enough successfully to interrupt the arc is necessarily so high as to confine the operation to severe discharges only.

A number of improvements have been made in this type of arrester to facilitate its action, especially on low voltages, such as providing auxiliary air gaps, etc. One of the best of these arrangements is that shown in Fig. 4. As soon as the condenser *C* attains the voltage for which the auxiliary spark gap *A* has been set the latter breaks down and a resonating ensues which excites the primary winding *P* of a high-frequency transformer. This induces in the secondary winding a high voltage which breaks through the main gap *K*, which is four or five times the length that would otherwise be required. This arrangement may be used for voltages as high as 6000. The magnetic blowout principle has frequently been applied with success to this type of arrester.

An electrolytic cell made up of two plates, one of aluminum and the other of some other metal, will allow current to flow through it freely in one direction, but in the opposite direction only a very small current can be forced through until the applied voltage reaches a certain value. When this "critical point" has been reached current flows very rapidly. If both plates are made of aluminum, the cell will allow no current to pass in either direction, so long as the voltage is below the critical value. If, however, the voltage exceeds this value, a very large current will flow which will cease as soon as the voltage drops again below the critical value. The cause of this action is a very thin film of hydroxide of aluminum which forms on the aluminum plates. A large number of plates are arranged in series by making trays of them and piling them on top of one another. A 13,000-volt unit consists of some 40 or 50 trays. These are put in stone jars fitted with tops so shaped that the jars may be put on top of one another. This type of arrester is very sensitive and will discharge freely without producing any appreciable effect on the operation of the system. However, it seems to lack capacity when it is subjected to very severe discharges; still, it gives great promise.

Use of Wires Strung Parallel to Power Wires

Several of the transmission companies

of this country have installed as a protection against lightning one or more wires strung parallel to the power wires and grounded at frequent intervals. There is a great diversity of opinion among men operating plants equipped with such devices as to the value of this scheme. Some say that the grounded wires afford no protection whatever unless they are located above the line wires; others say that they will do just as much good 2 feet below the line as 2 feet above it. Some operators report the best of protection as being afforded by the ground wires, others say they are a nuisance, since they are liable to break and fall across the line wires. Here is what Dr. Steinmetz says: "If a transmission line is inclosed by a grounded conducting shell, that is, put under ground, atmospheric disturbances cannot enter it. Since a transmission line cannot be put underground, the best available protection is to put the ground above it. A single grounded wire over a transmission line offers considerable protection from atmospheric disturbances, but two such wires are better than one and, naturally, the greater the number of wires the more perfect the protection afforded."

For satisfactory protection the line should be within the protective zone of the wires, that is, within a space inclosed by an angle of 45 or 60 degrees on either side of a vertical line drawn from the ground wires downward.

Ground wires alone are not sufficient protection, but they undoubtedly greatly relieve the disturbances which are produced in a line by electrical storms.

How to Run a Suction Gas Producer

By F. C. Tryon

In view of the relatively recent introduction of this class of power apparatus, it may not be out of place to suggest a daily procedure in starting and operating a suction gas-producer plant.

The operator should arrive at the plant at least an hour before the time to start the engines, unless there is employed a watchman who has been instructed what to do toward starting the producer. If the ashes were not removed the night before, the first duty should be the opening of the doors into the fire bed and ashpit, while the producer is still connected to the purge pipe, and the raking out of as much of the ashes as possible from immediately above the grate, taking special care to get out any clinkers that are down on the grate. With a little care a sufficient amount of ashes can be removed from above the grate without the body of fuel above being loosened and the fire running down upon the grate. After raking out all the ashes above the grate that are intended to be removed the doors to the fire bed should be closed and the blower should be started in operation. If this is driven by an auxiliary power, the ashes can be removed from the ashpit while the fire is being blown up. As soon as all the ashes are cleaned out, open the air inlet, if it has been closed during the shutdown, then close the ashpit doors. By this time the fire should have been sufficiently livened up to permit the barring of the fire bed down on the grate, sufficient ashes having been left at the bottom of the bed of fuel to protect the grate. As soon as the bed of fuel has been settled down and leveled off, the tamping bar should be used around the sides of the producer next the lining and the fire bed well packed to prevent the passage of air up alongside the wall of the producer where the falling down of the fire bed when barred has most likely left spaces.

After the fuel bed has been barred and tamped it is time to put on the necessary amount of fuel to supply the producer until the next regular feeding time. By this time the fire should be in a condition to make a gas that will ignite at the test tube, and the passage of the hot gases through the pipe to the purge should by this time be making sufficient steam or vapor and this should be opened and connected to the air inlet so that any additional air drawn into the producer is mixed with the proper amount of steam or vapor. If the gas has been too weak to ignite at the test tube before this, it will probably light now without difficulty.

Before the gas delivery is changed from the purge pipe to the wet scrubber, water should be turned onto the sprinkler at the top of the scrubber and allowed sufficient time to wet the baffling materials and show at the overflow pipe at the bottom of the wet scrubber. The gas can then be turned into the wet scrubber. The test flame at the engine should then be opened; as soon as the gas will burn, it is ready for use in the engine and the blower should then be stopped. If coal is elevated into a bunker or storage bin at the producer top this is the proper time to see that the required amount is stored ready for the next charging.

While the fire is fresh and needs little attention, there is an opportunity for a general clean up of the producer room. Sweep up all ashes, clinkers and dust of every kind; if there is a good concrete floor properly arranged for drainage, use the hose and wash down all dust and ashes from the walls and floor. A producer-gas plant can be kept almost as neat and clean as an office if given proper care and attention.

The operator should bear in mind that the engine is consuming so much coal per hour, that the coal contains a certain percentage of ashes, that the bed of fuel in the producer is being consumed at all parts and in a short time each piece of

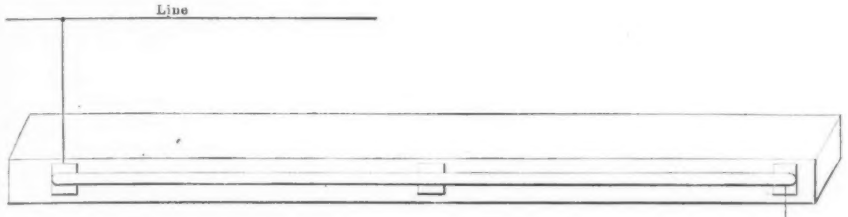


FIG. 2

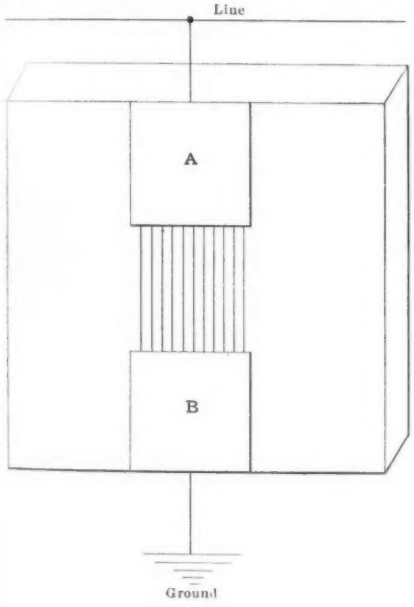


FIG. 3

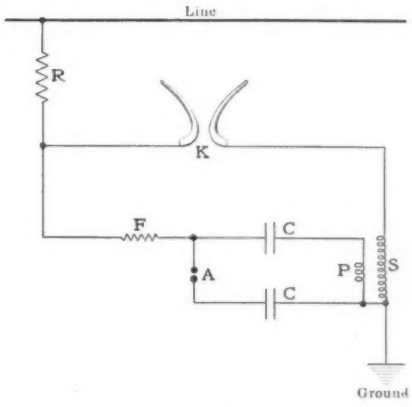


FIG. 4

coal will be covered with a film of ashes. If the fire is not occasionally disturbed, these ashes will prevent proper contact of the air with these pieces of coal and combustion will be retarded or stopped. The operator must learn from experience about how often it is necessary to poke the fire in order to secure the best results. The poking of the fire bed to dislodge ashes should always be done through the side poke holes, not from the top. Top barring, except when done thoroughly, to work the entire fire bed down, is liable to leave chimneys or vertical passages up through the fire bed and the air will pass up these, burning the distilled coal gas and producing heat intense enough to fuse the ashes and make clinker. Top barring should be done just before feeding in fresh coal, while a producer is in operation.

The operator can usually tell from observation through the peep or side bar holes when the fire needs barring. If the fire in any particular part of the bed is growing hotter than at other places it shows that the fuel bed is looser at that place and needs packing down to force the passage of air more generally through the whole fire bed. Chimneys will be plainly discernible by the intense white heat around them. Lack of circulation of air at any point in the fire bed is indicated by a dark space, or coal hardly red. If the entire fire bed is getting too hot, it is better partly to close the air inlet or increase the rate of steam supply, or both. If the engine will not permit the increase of hydrogen due to the larger proportion of steam, and commences to give pre-ignition, then the tamping bar must be used from the top of the producer and the entire fire bed packed more closely.

Sometimes the fire bed seems to be all right from observations through the peep holes, yet the engine shows signs of distress and changes at the mixing valve do not give próper relief; a peep in the holes at the top of the producer will probably show the cause. A passage up through the fire bed will probably be found, most likely next to the wall, and the air thus admitted will burn the gas above the fuel bed, so that the engine will get only a small portion of carbon monoxide and a large portion of carbon dioxide. Sometimes the addition of more fuel will stop these air passages. If it is near the regular time for feeding coal to the producer this is the best remedy to try first; if not, then use the tamping bar.

If the load on the engine is a fairly constant one, it is well to put in fresh coal at stated intervals. The operator then knows very closely how much fuel there is in the producer, the depth of the fuel bed, etc. If the producer is ample in size for the power the engine is developing, load fluctuations will have very little effect on the fuel bed and it need not be watched as closely as would be necessary if the engine load were close to the producer capacity. In the latter case the fire must be watched closely when full load lasts for any length of time, as it will blast the fire into an intense white heat, in which condition it easily makes clinkers or blowholes or both.

At the noon hour, it is generally considered the better practice to continue the engine in operation, running light. If the engine is belted to a line shaft, the clutch coupling connecting the driving pulley to the main shaft can be thrown and the engine relieved of all load except its own friction. There is little fuel consumed during this time and the fire in the producer is kept in better condition than if all draft on it was stopped. However, if there is anything the matter with the producer plant that cannot receive proper attention while running, it is better to stop the engine during the noon hour and repair or fix the producer than to take any chances of waiting until night and perhaps have to shut down during the afternoon run. During the noon hour, while the engine has no load on, is a good time to bar the fire, work down the ashes and put on fresh fuel, and work the fire up into good condition so that when the load is again thrown on there will be no question of the ability to provide gas of the proper quality and quantity.

There are some suction producers in which the amount of coal required for the entire day is supplied at one time, usually in the morning. If the gas is taken off near the top of the producer or above this body of coal it is questionable if this is a good practice, as it makes it almost impossible to bar the fire through so heavy a body of fuel, and blow-holes or chimneys are not as easily located or corrected. To bar a fire properly from the top while the producer is in operation is not an easy job at any time; the hole through which the poke bar is used is small, because the space around the poke bar when in the hole must be restricted or sufficient air would be drawn in during the operation to burn the gas being made; therefore, barring down is very largely blind work, guided more by calculation and feeling than by sight, and it should be done only when necessary. The necessity will probably occur less often without an unnecessary depth of fuel in the generator.

When the day's work is done and the engine stopped, the gas should be immediately switched into the purge pipe and shut off from the wet scrubber, all water supply to the wet scrubber and generator shut off and the air-inlet pipe to the generator closed. The generator cannot make gas unless supplied with air or steam, and if all supply of both these be stopped, the fire in the producer will only smoulder during the shutdown. Many operators prefer removing the ashes at night instead of waiting until the morning. If the ashes are raked out at night and the fuel bed does not fall down into the space cleaned, but binds to the side walls and remains suspended, it is better to leave it up away from the grate to allow the grate to cool. Then the operator has only to bar his fuel bed in the morning after the blower has livened the fire.

The kind of coal to use in a gas producer is a matter requiring considerable attention. The most prolific source of trouble in the operation of a producer is clinker. It chokes up the fire bed, obstructs the passage of air through it, prevents the working down of the ashes and interferes with everything generally. Clinkers should be barred down and removed as soon as possible after discovery. They are not always due to lack of attention. Some kinds of coal make clinkers very easily, and it is almost impossible to keep up a good fire with such coal without fusing a portion of it and making these troublesome lumps. Coal containing a large percentage of slate is also liable to contain a large percentage of sulphur and some iron. Such coal should be avoided for use in producers.

Power Required by Motor Driven Centrifugal Pumps

By N. A. Carle

Centrifugal pumps driven by electric motors are utilized extensively to pump water for irrigation purposes where the head to be pumped against, including elevation, suction and friction, is less than 50 feet. There is no mechanical reason for thus limiting the head, but the cost of power per unit of water pumped becomes too great with higher heads for ordinary commercial conditions. There are many special cases where the water is valuable enough at the higher cost to pump it to any hight mechanically possible, but land values, increased production by the use of water, cost of water rights, maintenance of ditches, etc., have combined to set a limit of 50 feet for this kind of irrigation.

The sizes of pump range from 4 to 8 inches for isolated plants serving a single consumer. Although there is a large amount of electric pumping for irrigation, there is also a considerable use for these pumping outfits for sump pumps, hot-well pumps, sewage and drainage.

The capacity of a centrifugal pump depends upon the velocity of discharge for which it is designed. The horsepower of the electric motor necessary to operate the pump depends upon the quantity of water to be pumped, the total head pumped against including elevation, suction and friction heads, the pump efficiency and the motor efficiency.

The chart on page 823 is intended to show graphically the horsepower of an

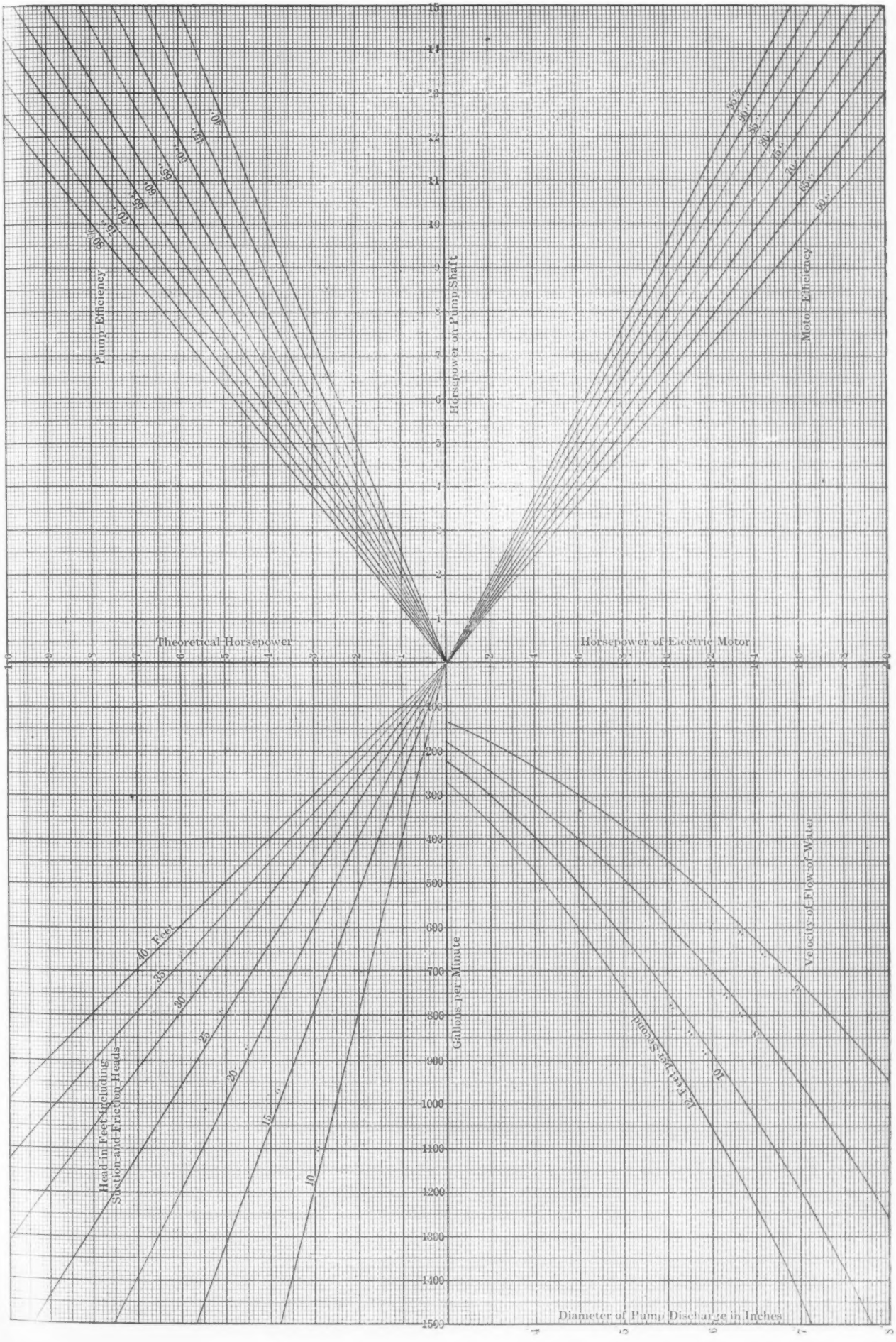


CHART FOR DETERMINING POWER REQUIRED BY MOTOR-DRIVEN CENTRIFUGAL PUMPS

electric motor necessary to pump water up to 1500 gallons per minute against heads of from 10 feet to 40 feet, with pump efficiencies of from 40 to 80 per cent. and motor efficiencies from 60 to 95 per cent.

There is also shown the number of gallons per minute delivered by pumps from 4 to 8 inches diameter of discharge with a velocity of flow from 6 to 12 feet per second in the discharge pipe.

EXAMPLES

(1) How much electrical horsepower will be required to operate a 6-inch centrifugal pump having a discharge velocity of flow of 12 feet per second, pumping against a combined friction, suction and actual head of 25 feet, assuming a pump efficiency of 65 per cent. and a motor efficiency of 85 per cent.?

Starting with 6 inches diameter of pump discharge read across to 12 feet per second, then up to 1060 gallons per minute, which is the output capacity of the pump. From this point read up to 25-foot head, then across to 65 per cent. pump efficiency, then down to 85 per cent. motor efficiency and across to 12.1 "horsepower of electric motor."

(2) How much water can be pumped with a 20-horsepower electric motor having an efficiency of 75 per cent., driving a 7-inch centrifugal pump having an efficiency of 65 per cent., pumping against a total head of 40 feet; and what will be the velocity of flow of the pump discharge?

Starting with 20 horsepower of electric motor and going counter-clockwise, read across to 75 per cent. motor efficiency, then up to 65 per cent. pump efficiency, then over to 40 feet head, and then down to 960 gallons per minute, which is the output capacity of the pump. Dropping a line from this point to its intersection with a horizontal line through 7 inches diameter of pump discharge, the velocity of flow is found to be 8 feet per second.

(3) What sizes of pump and motor are necessary to handle 1200 gallons of water per minute against a combined friction, suction and actual head of 30 feet, allowing a velocity of flow by the pump discharge of 10 feet per second and a pump efficiency of 75 per cent. and a motor efficiency of 80 per cent.?

Starting with 1200 gallons per minute, drop down to 10 feet per second velocity of flow, trace thence across to 7 inches diameter of pump discharge. Then starting again with 1200 gallons per minute read up to 30 feet head, then across to 75 per cent. pump efficiency, then down to 80 per cent. motor efficiency and then across to 15.2 "horsepower of electric motor."

Coal Handling in a Large Plant

The coal-handling apparatus installed in the Delaware avenue power house of the Philadelphia Rapid Transit Company consists of two elevators and five conveyers, designated as elevators *A* and *B*, and conveyers Nos. 2, 3, 5, 8 and 10, provision being made for the installation of Nos. 1, 4, 6, 7 and 9 when the demands of the plant require it.

Elevator *A* was installed for the handling of anthracite. This elevator is of 100 feet centers and discharges into conveyer No. 2, which is of 116 feet centers. The buckets on elevator *A* are 24x18x12 feet, made of 3/16-inch steel, and are continuous on the chain. The coal is fed to elevator *A* through a hopper underneath the railroad tracks alongside of the power house. Conveyer No. 2, which is 116 feet long, runs directly over a concrete storage bin and is fitted with discharge gates to permit of the even distribution of the coal.

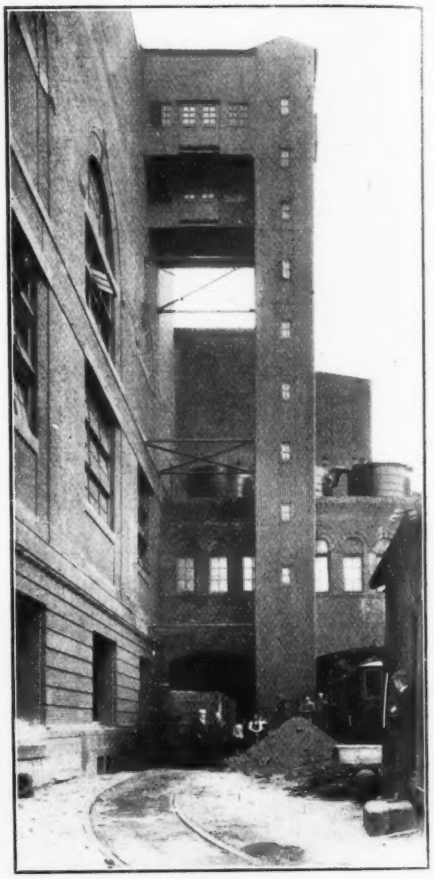


FIG. 1. ELEVATOR "A" OF DELAWARE AVENUE PLANT

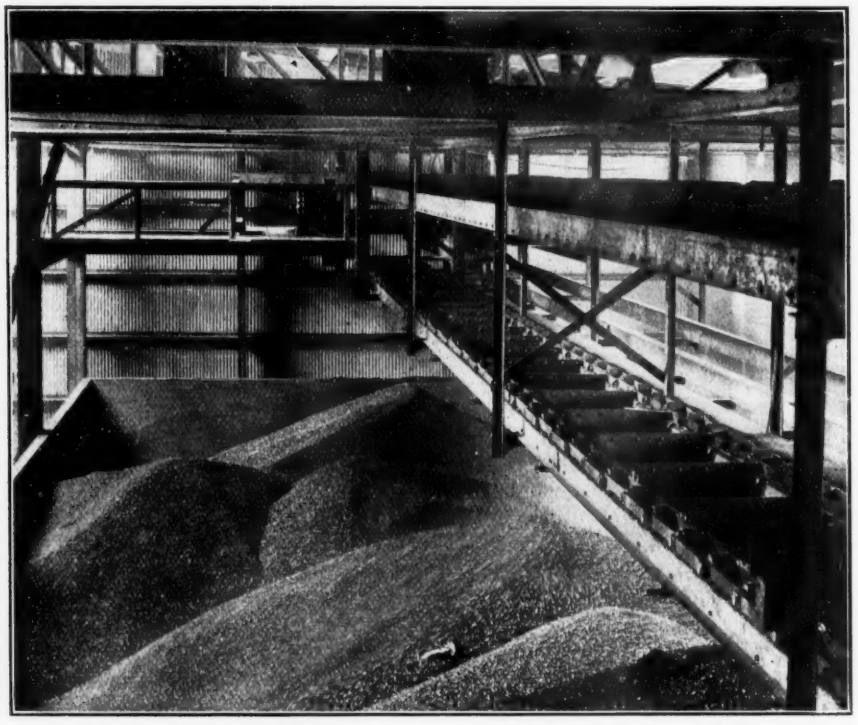


FIG. 2. CONVEYER NO. 2 HANDLING ANTHRACITE

Elevator *B* is situated on the east side of Delaware avenue and receives coal through a crusher from conveyer No. 8, which is fed by conveyer No. 10, the last-named conveyer being fed by Webster improved feeders attached to three track hoppers underneath the railroad tracks. The material is delivered into these hoppers from railroad cars or small transfer cars which are filled by a locomotive crane from boats at the end of the wharf. Elevator *B* is of 100 feet centers, conveyer No. 8 is 215 feet long and conveyer No. 10 is 55 feet long. The buckets on elevator *B* are of the V-type, 28 inches long, 20 inches wide and 9 inches deep, made of 3/16-inch steel. Elevator *B* discharges coal into conveyer No. 5, which is carried on a bridge over Delaware avenue. Conveyer No. 5, 169 feet centers, discharges into conveyers Nos. 3 and 2, these being the conveyers over the bins on opposite sides of the power house. The centers of

FIG. 3. RECEIVING END OF CONVEYER NO. 2 AND SPOUT FROM ELEVATOR "A"

conveyer No. 3 are 89 feet apart, and the conveyer is fitted with valves for distributing the coal over the bunker, the same as conveyer No. 2.

The crusher is of the two-roll type, fitted with 30x30-inch cast-steel rolls. A screen is placed at the end of the trough of conveyer No. 8, with a bypass in the spout to the crusher to prevent the fine material passing through the crusher. A gate is also provided at the end of this trough for use when anthracite is being conveyed to prevent its passing through the crusher.

The difficulty in maintaining the flow of coal to the conveyer under the track hopper, particularly when bituminous coal is being handled, is believed to be overcome by the use of the Webster pusher which operates on a short length of track beneath the hoppers. This device consists of three cast-iron pushers operating in a metal trough, each pusher being supported on rollers and driven by an eccentric. The three eccentrics are on one shaft and may be individually engaged or disengaged by means of jaw clutches. The shaft on which the eccentrics are mounted is driven by belt from an independent 10-horsepower motor. Under each of the pushers is a small screw conveyer for carrying away dust, which would otherwise have a tendency to clog the pushers. These small conveyers deliver the dust into the conveyer under the hoppers.

All the conveyers are fitted with 30x12-inch flights made of ¼-inch steel. Each flight is connected to two strands of chain by means of a ⅝x2-inch bar running entirely across the flight. The

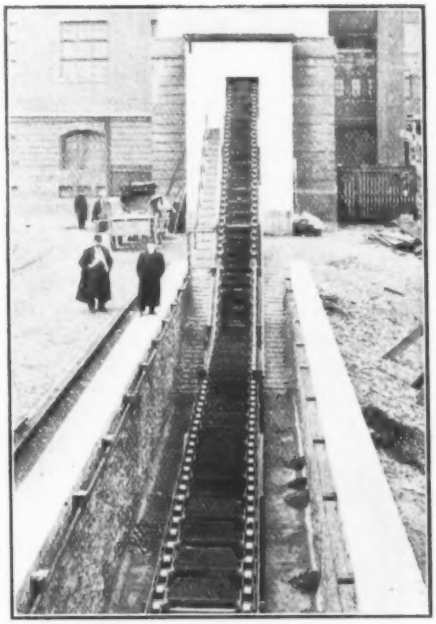


FIG. 5. CONVEYER NO. 8 AND TOWER CONTAINING ELEVATOR "B"

FIG. 4. CONVEYER NO. 5 AND HEAD OF ELEVATOR "B"

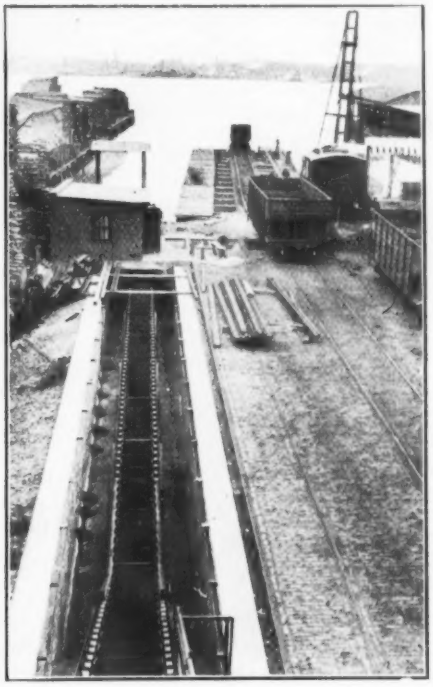


FIG. 6. CONVEYER NO. 8 AND TRACK HOPPER OVER CONVEYER NO. 10

troughs are all 3/16-inch steel, V-shaped, with flat bottoms held in place by screws secured to the 4x8-inch carrying timbers which are bolted to channel irons. On top of all channel irons are placed ⅝x3½-inch steel bars which serve as tracks. The chains for all elevators and conveyers are of the same size and consist of ⅜x2½x18-inch drop-forged links, the ends of which are ¾ inch thick at the pin holes. The pins are all 1½ inches in diameter and 7½ inches long. The chain rollers are 5 inches in diameter, 3-inch face and are self-oiling; the faces are chilled.

The speed of all conveyers and elevators is 100 feet per minute. They are all direct-connected to motors with the exception of conveyer No. 5, which employs silent-chain drive. The bins which hold the coal over the boilers have a capacity of 1000 tons and are made of concrete. These bins are fitted with chutes to the stokers with which all boilers are fitted. The Webster Manufacturing Company, of Chicago, designed and furnished all the elevating and conveying machinery, and the supporting steel work, through its Philadelphia office.

FIG. 7. INCLINED PORTION OF CONVEYER NO. 8

Something for Nothing

By F. L. Johnson

My young friend's description of his visit to a steam plant was cut short by the entrance of a stranger with a roll of drawings and a bundle of photographs. After the usual preliminaries, he proceeded to describe an apparatus, designed, he said, to improve the efficiency of boilers and steam engines. The apparatus, as described, consists of an air compressor and receiver to be used in conjunction with a boiler and engine, as follows:

The compressor is actuated by steam drawn from the boiler, and compresses air to a pressure 50 per cent. above that of the steam in the boiler. This air is then led from the compressor, through a series of small receivers placed in the combustion chamber of the furnace, into the lower part of the boiler and there discharged through a perforated pipe into the water. The claims made for the apparatus are increased rapidity of circulation, increased evaporation caused by the intimate mixture of hot air with the water and an increase in volume of the mixture of steam and air, resulting in an increase of work from a given quantity of fuel. I could not help seeing that my young friend was an interested listener, so I opened a way for him to enter the discussion of the merits and demerits of the combination. He at once asked if there had been any tests and was told that a very exhaustive test had been made, which proved that a saving of 22 per cent. in fuel was possible by the use of the air-injecting device. The description of the test, as nearly as I can remember, was as follows:

"The object of this device is to increase the efficiency of steam boilers by injecting into the water within the boiler jets of heated compressed air, with the idea of increasing the rate of evaporation and the rapidity of circulation. This system, as developed thus far, consists in applying to a boiler, as for instance an ordinary tubular boiler, means for injecting into the water a continuous flow of hot compressed air. The air is supplied by a steam-actuated air compressor and is heated by being pumped through a series of steel tanks or heaters located in the combustion chamber of the boiler. The air is first compressed, then heated, then introduced into the water of the boiler through a long, perforated pipe located within the water space near the bottom of the shell. The outfit, as tested, consists of a horizontal tubular boiler, an air compressor, an engine and a steam-driven boiler-feed pump. Both the air compressor and the feed pump took their steam directly from the boiler, which also supplied steam for the engine.

"The object of the test was to compare the economy of the plant run without the air device with its economy when the air device was in use, care being taken to keep the conditions of the two tests as nearly the same as possible. It was not practicable to attempt to reduce the results to the form prescribed by the American Society of Mechanical Engineers' standard by weighing the feed water; therefore, it was decided to make merely a comparative test of the boiler with and without the apparatus, keeping the load on the boiler constant throughout the two tests, and check the economy by comparing the coal consumed in one case with that consumed in the other.

"In the first test in which the apparatus was used, it was necessary to run the air compressor to pump air into the boiler at a pressure higher than the steam pressure. In the second test, in which no air was used in the boiler, the air compressor was operated against the same pressure as in the first test, but the air was blown into the atmosphere through a throttling valve. In both tests the feed pump operated under the same conditions, making the same number of revolutions against the same pressure. This was accomplished by arranging a bypass valve in the feed-pump discharge and providing a gage in this discharge pipe by which the back

pressure on the pump could be kept constant. In both tests the engine equipped with a prony brake was run at the same number of revolutions per minute and against the same brake load. The water level in the boiler was kept constant throughout both tests and at the beginning of each test the fires were cleaned and all ashes removed from the ashpit.

"During the tests the coal was weighed on platform scales and at the end of each test the fires were brought to their initial condition. The ashpit was cleaned, the ashes weighed and the coal weights checked up. The same fireman was employed on both tests and as nearly as possible all conditions of running were kept identical. It is to be noticed that in the first test in which the air was used, the two pre-heating tanks operated in extent as part of the heating surface of the boiler and the feed water used on that test was admitted to the boiler through the ordinary feed lines. In order to keep the two tests the same, it was decided on the second test to use these two preheating tanks as feed-water heaters, therefore the feed water was admitted to the boiler through these tanks.

"The duration of each test was exactly ten hours. By means of the stroke counter on the feed pump and air compressor and the compressor gages on their discharge lines, it was possible to keep them operating on both tests under exactly the same load; in fact, the total strokes of the feed pumps and the total strokes of the air pumps on each of the two tests were respectively the same. In the first test, that in which the air system was used, there was burned 868 pounds of coal, and in the second test, that in which the boiler was used without the air device, there was consumed 1058 pounds of coal, or a difference in favor of the apparatus of 190 pounds; in other words, 22 per cent. more coal was consumed when the plant was run without the air apparatus than was consumed with the apparatus in use."

At the close of this convincing description, my friend asked the following questions:

"What power was developed by the engine? What power was used in operating the air compressor? How many feet of free air were compressed per hour? What was the temperature of the feed water on the day that the air apparatus was used? How many pounds of water were evaporated from and at 212 degrees in each case?"

The promoter looked him over in an indulgent sort of way and then said:

"You are evidently not familiar with engine or boiler trials, or you would see that as the work done by the engine and the compressor was the same in both instances, it was only necessary to measure the fuel burned; all the other factors in the operation were the same in both tests, which proves a saving by the use of the apparatus."

"Yes," said the young man. "If the work done by the machines operated was the same in both cases; but as long as you do not know what work was done by either machine, I do not see that you have any license to tell me that the work was the same. It may be that you can take steam from a boiler to run an engine which drives an air pump which forces air into a boiler and get more power from the boiler than it takes to operate the air pump, but if you do, it will be because you are putting more into the boiler in some other way. In your arrangement, you are converting heat into mechanical work in compressing the air which is forced into the boiler, where, as you claim, it gives up more heat than has been put into it. It is generally considered that this is impossible, and although you claim to have accomplished it, you produce nothing to prove your case except an alleged record of a couple of counting machines and the statement that you burned on one day about 200 pounds more coal than you did upon another day, and the only work that you know anything about to a certainty is that the counting machines registered the same number of strokes on both days, and you call that a test."

The promoter was plainly angry, but he said mildly enough:

"This test was conducted by a reputable engineering company, and they are putting their business reputation and wealth behind it. You may rest assured that such men would not take up anything of this sort until they were satisfied that it was all that it was represented to be."

My friend replied:

"This is leading away from the question of the possibility of a successful operation of your perpetual-motion scheme—for it is nothing if it is not that, since its aim is to get more out of a machine than is put into it—to the question of present-day commercial morals; and your assumption of the honesty of your engineering company is, to say the least, an assumption unwarranted by the conduct of other business corporations and the behavior of many public officials at the present time.

"As straws tell which way the wind blows, so do a few examples speak volumes on the status of the present business conscience. The management of a prosperous and profitable railroad issues millions of dollars of worthless bonds on an unimproved right of way. A man who is president of one reputable manufacturing company, and the general manager of another lends his business reputation to the project of vending a worthless nostrum for the alleged purpose of making fuel from clinkers, and the School Board of the City of New York, I am told, was paying $5.80 per ton for coal when the market price is about $3.60, and so on. These things are of common knowledge and only go to show that the end and aim of all business today is profit, to get as much of the other fellow's money as possible for as little return as may be. It matters not that the thing is worthless and that the venders know it.

"Giving short weight, selling damaged and misrepresented goods and loading the market with adulterated foods are not crimes punishable by imprisonment, but simply misdemeanors which may be settled for by the payment of a small fine, and in the conscienceless scramble for profits all become tainted. Doubtless your engineering company is no exception to the rule, for if the company is reputable it has achieved its reputation by doing good work at some time in the past. If so, the worthlessness of this air device is well known; if not so, the backers of this scheme are ignorant of the fundamentals of engineering and, in either case, are attempting, ignorantly or otherwise, a swindle.

"But I did not mean to be led into a discussion of the ethics of modern business. In the operation of your air-injector system and its test, the vital points have been omitted. A test is usually conducted for the purpose of determining something. In the case of the air-injector system which you propose, and which you say was tested, the point to have been determined was: Will a pound of coal do more work when the air system is used than when it is not? This you cannot tell, because you do not know how much work was done in either case. The work of operating the machinery appears to you to be the same in both cases, and it would be expected that less coal would be burned on the day that the apparatus was used, because a part of the heat which was used to operate the air compressor was returned to the boiler, which under the other so-called test was blown into the atmosphere.

"That more heat was returned to the boiler than it took to operate the compressor, however, is doubtful, and why was not the compressed air, instead of being wasted or blown into the atmosphere, piped to the steam chest of the engine, where it could be used to produce power and reduce the amount of coal burned, the same as in the first test? Of course, practical engineers, who know something about the mechanical and chemical problems to be met with in the operation of such an outfit, will at once condemn it and give their reasons for so doing, but the young engineer and the short-sighted owner, who may be led to expect something for nothing, will help to prove the old saying that 'there is a sucker born every minute.'"

The promoter rolled up his drawings, mumbled something about engineers and editors knowing little or nothing of the value of advertising, put on his hat and said: "Good day."

The Low Pressure Steam Turbine*

Discussion of the Uses to Which It May Be Applied with Advantage; Two Noteworthy Installations, with Performance Records

The low-pressure turbine is designed to take steam at one pound gage pressure and efficiently utilize its energy in the lower ranges to one-half pound absolute, or, in other words, a 29-inch vacuum, at water rates from 30 to 50 pounds per kilowatt-hour at the switchboard, in accordance with size and local conditions.

The low-pressure turbine can be advantageously applied in any case where reciprocating engines are now used, and their application will always afford a large improvement of economy and increase the power output without increase of boiler plant. This applies whether engines are now operated condensing or noncondensing, delivering their output electrically or mechanically, and also applies to engines which operate on intermittent loads, since the delivery of low-pressure steam can be equalized by suitable steam-regenerating apparatus.

Running noncondensing may be legitimate with reciprocating engines, because the gain by condensation with such engines is comparatively small and in many cases may not pay for the additional complication and expense incident to the installation and operation of condensers. If low-pressure turbines are used, however, we can expect to obtain about as much power from the turbine working below the atmosphere as we do from the engine above the atmosphere, and with this great gain obtainable there can be no question as to the economy of installing condenser facilities and low-pressure turbines, even where cooling towers would be required. A 1000-horsepower noncondensing-engine plant was operated 3000 hours per year at 2.5 pounds of fuel per horsepower or 3750 short tons of coal per year. By the addition of a 1000-horsepower low-pressure turbine with a suitable cooling tower capable of maintaining a 28-inch vacuum, the plant was made to deliver 2000 horsepower 3000 hours per year at 1.25 pounds of fuel per horsepower-hour, or 3750 short tons of coal per year. The plant as doubled in output required no addition to the boiler equipment nor was any additional labor made necessary.

Field for Low-pressure Turbines

The most ready field for the introduction of low-pressure turbines is found in existing condensing plants which operate with reciprocating engines. Where low-pressure turbines are installed, the exhaust pressure of the reciprocating engines will be above that of the atmosphere. There will, therefore, be no air leakage around piston rods and valve stems, and it will be possible to maintain better degrees of vacuum than those which are generally attained in condensing-engine plants where there is more or less leakage of air and little incentive for the production of high vacuum.

The possibilities of the low pressure will be more readily understood if we consider the available work in different ranges of steam pressure. If saturated steam operates from a pressure of 150 pounds gage to a pressure of one pound above the atmosphere, the available energy is about 132,000 foot-pounds per pound, and if saturated steam operates from a pressure of one pound of steam above the atmosphere to a vacuum of 28½ inches, the available energy is 146,000 foot-pounds per pound of steam. In a mixture of steam and water issuing from an ordinary steam engine exhausting at a pressure of one pound above the atmosphere, the above available energy is reduced to about 132,000 foot-pounds per pound if we work to a vacuum of 28½ inches. Thus under these very ordinary conditions there is as much work available in the low-pressure ranges as in the high-. Efficiency in these low-pressure ranges is better than the high-pressure part, while in the reciprocating engine the return from the low-pressure steam is relatively very small.

In most condensing engines the gain over noncondensing conditions does not exceed 30 per cent., even under the most favorable conditions of load, and under overload conditions the gain by condensing is much smaller. In most cases a reciprocating engine which is operated condensing will give at least 75 per cent. of the output with the same steam used in noncondensing. This steam being taken into a low-pressure turbine with good condensing facilities will add nearly, if not quite, as much work as it gives in the engine. We can, therefore, under ordinary conditions get a net gain of 50 per cent. over existing condensing-engine service by installing low-pressure turbines, and under overload conditions where the efficiency of the engine falls off and where its gain by vacuum is greatly diminished.

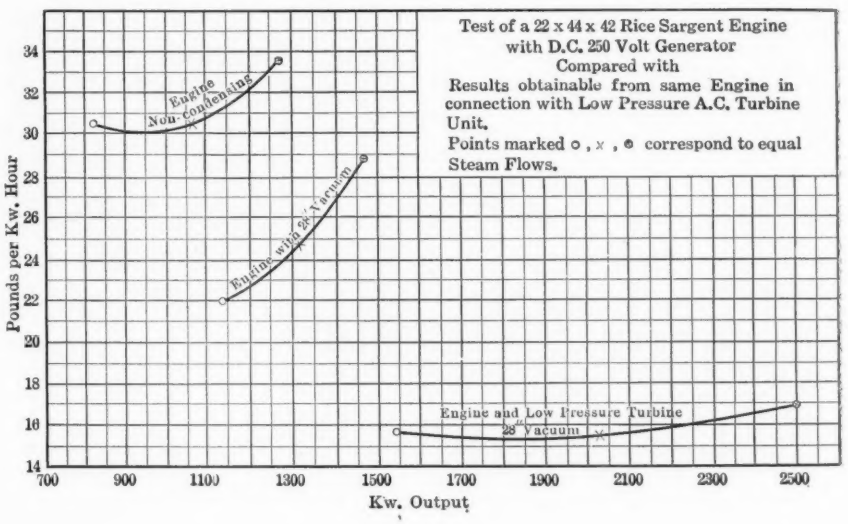


FIG. I

and if saturated steam operates from a pressure of one pound of steam above the atmosphere to a vacuum of 28½ inches, the available energy is 146,000 foot-pounds per pound of steam. In a mixture of steam and water issuing from an ordinary steam engine exhausting at a pressure of one pound above the atmosphere, the above available energy is reduced to about 132,000 foot-pounds per pound if we work to a vacuum of 28½ inches. Thus under these very ordinary conditions there is as much work available in the low-pressure ranges as in the high-. Efficiency in these low-pressure ranges is better than the high-pressure part, while in the reciprocating engine the return from the low-pressure steam is relatively very small.

In most condensing engines the gain the rate of improvement will be much better.

Fig. 1 shows a study of possibilities in connection with a Rice-Sargent engine which has been operated for some years in our own plant at Schenectady. The upper curve represents the engine operating noncondensing at 810 kilowatts, the steam consumption being 30.6 pounds per kilowatt. With the load increased to 1065 kilowatts, the steam consumption is 30.6 pounds per kilowatt, and with the load increased to 1265 kilowatts, the steam consumption is 33.6 pounds; and, operating under these conditions, 1265 kilowatts is practically the maximum capacity of the unit.

Operating condensing with a capacity of 1140 kilowatts the steam consumption is 22 pounds, at 1320 kilowatts 24.6

*Abstract of a paper read before the National Association of Cotton Manufacturers, September 29-30, 1908, by Charles B. Burleigh.

pounds, and at 1470 kilowatts 28.8 pounds per kilowatt-hour, but the maximum capacity of the unit has been increased from 1265 to 1470 kilowatts.

By the assistance of the low-pressure turbine, vacuum conditions remaining the same, the steam consumption at 1550 kilowatts is 15.6, at 2020 kilowatts 15.4, and at 2500 kilowatts 17 pounds per kilowatt-hour, and the maximum output of the unit has been increased from 1265 kilowatts noncondensing, to 2500 kilowatts, or from 1470 kilowatts condensing to 2500 kilowatts.

Note that the number of pounds of steam necessary to deliver 2500 kilowatts by the use of the engine and turbine condensing is practically the same as the amount required to deliver 1480 kilowatts from the engine operating condensing without the turbine, and also practically the same as was required to deliver 1265 kilowatts from the engine operating noncondensing.

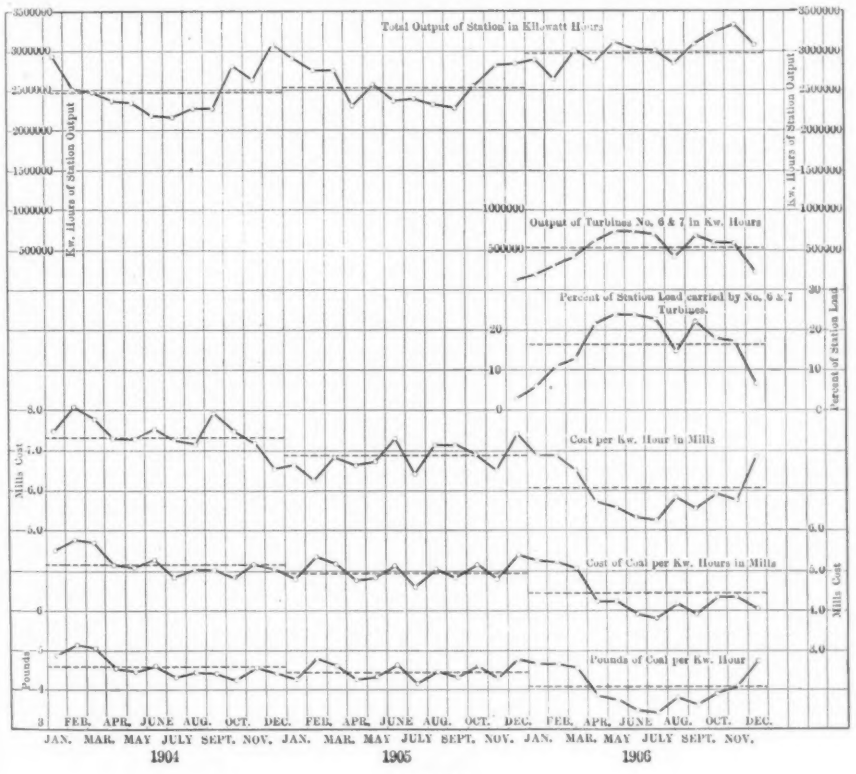

Total Output of Station in Kilowatt Hours
Kw. Hours of Station Output
Output of Turbines No. 6 & 7 in Kw. Hours
Percent of Station Load carried by No. 6 & 7 Turbines.
Percent of Station Load
Cost per kw. Hour in Mills
Mills Cost
Cost of Coal per Kw. Hours in Mills
Pounds of Coal per Kw. Hour
Pounds
FEB. APR. JUNE AUG. OCT. DEC. FEB. APR. JUNE AUG. OCT. DEC. FEB. APR. JUNE AUG. OCT. DEC.
JAN. MAR. MAY JULY SEPT. NOV. JAN. MAR. MAY JULY SEPT. NOV. JAN. MAR. MAY JULY SEPT. NOV.
1904 1905 1906

FIG. 2

Philadelphia Rapid Transit Installation

The Philadelphia Rapid Transit Company in 1905 installed at its power station on Thirteenth and Mt. Vernon streets an 800-kilowatt Curtis low-pressure turbine. This station was equipped with four 1500-horsepower and one 2200-horsepower Wetherill Corliss engines which had always been operated noncondensing for the reason that cooling water was not available.

An Alberger condenser having 8000 square feet of cooling surface, together with a cooling tower, was installed for use with the low-pressure turbine. The average vacuum obtained is 28 inches. The turbine takes steam from the common exhaust main at a pressure of one pound above the atmosphere and is provided with four wheels, each with a single row of buckets.

Exhaust steam from one engine when delivering 2000 amperes is sufficient to deliver an output from the turbine of 1300 amperes, with no increase of back pressure on the engine. As about 150 amperes are required to operate the auxiliaries the net gain from the turbine is from 1000 to 1200 amperes, or approximately 66⅔ per cent.

As the maximum gain possible from the use of a condenser without the turbine would not exceed 25 per cent., it will be seen that the turbine produces a gain of 41⅔ per cent. over this arrangement.

With the turbine taking steam at atmospheric pressure with 2 inches absolute back pressure in the condenser, a water rate of 36 pounds per kilowatt is guaranteed at full load. The conductors from the turbine generator are connected by common busbars with the leads from the engine-driven units. As before stated, this turbine is peculiarly simple, consisting of nothing only the wheels, shell and generator without governor.

If the engine-driven generators tend to take more than their proportion of load, the engine governors admit an additional volume of steam to produce the necessary energy, and the engines in turn deliver more steam to the turbine, tending to speed it up, thus increasing the voltage on the turbine-driven generator, which tends to take more work, thereby lightening up on the engine-driven generators, which makes the regulation automatic.

As the load conditions were such as required further increase, a second 800-kilowatt Curtis low-pressure turbine, condenser and cooling tower were installed early in 1906 under similar conditions, taking steam from the same exhaust header and delivering current to the common busbars.

All the auxiliaries required in connection with the turbines, condensers and cooling towers are motor-driven, with the exception of two dry-air pumps, one step-bearing pump and two discharge pumps, the exhaust from which is utilized for heating the feed water, and the current required to operate them is about 14 per cent. of the output of the turbines.

The coal consumption for all purposes at this station the first six months of 1905, before the turbines were installed, averaged 4.48 pounds per kilowatt-hour.

The coal consumption for all purposes for first six months of 1906, after the turbines were installed, averaged 4.08 pounds per kilowatt-hour, showing a saving of 0.4 pound of coal per kilowatt-hour.

As the total output of the station for the first six months of 1906 was 20,346,890 kilowatt-hours, this shows a saving of 4069 tons of coal, or 8138 tons for the year, which, figured at $3 per ton, amounts to $24,414.

Looking at this plant from a first-cost point of view, the original steam equipment cost somewhere in the neighborhood of $100 per kilowatt, and to have increased their capacity on its original lines would have required an investment proportionately equal to the original investment; the low-pressure turbines, with cooling towers, however, were installed at an expense of approximately $50 per kilowatt, and as the turbines were utilizing the energy in the steam previously unused, the fuel consumption was not increased a pound, or, in other words, considering one of the 1500-kilowatt units operating with one of the 800-kilowatt low-pressure turbines, under the new arrangement 2300 kilowatts was made available at no more expense as regards fuel and attendance than was previously necessary to deliver 1500 kilowatts to the distributing mains.

Records of Performance

Fortunately I am permitted by the purchaser to present for consideration the curve sheet, Fig. 2, which is a complete record of the performance of this power plant for a period of three years from January, 1904, to January, 1907.

It will be noted that during the year 1904 the engines were operated alone under normal conditions, with the following results:

Average kilowatt-hour output per month	2,475,000
Average cost per kilowatt-hour	7.3 mills
Average cost of coal per kilowatt-hour.	5.15 mills
Average pounds of coal per kilowatt-hour	4.6 mills

These conditions prevailed till January, 1905, when the first 800-kilowatt low-pressure turbine was put in operation and the conditions prevailing from January, 1905, to January, 1906, were as follows:

Average kilowatt-hour output per month	2,500,000
Average cost per kilowatt-hour	6.9 mills
Average cost of coal per kilowatt-hour	4.97 mills
Average pounds of coal per kilowatt-hour	4.47 mills

Showing that the addition of this low-pressure turbine, amounting to an increase in station capacity of a little over 10 per cent., delivering an increased average amount of power to the extent of 10 per cent., used less coal to the extent of 210,000 pounds, or 105 short tons, per month; or, in other words, an expenditure of approximately $40,000 enabled the purchaser to deliver 25,000 additional kilowatt-hours per month and sell the same at a profit, and at the same time save 105 tons of coal per month; or, stated differently again, the plant actually delivered 10 per cent. more power with approximately 2 per cent. less fuel incident to the installation of the first low-pressure turbine.

In January, 1906, the second 800-kilowatt low-pressure turbine was put into service. Let us examine the result and again draw comparisons. We find the following conditions for the year, January, 1906, to January, 1907:

Average kilowatt-hour output per month	2,957,500
Average cost per kilowatt-hour	6.03 mills
Average cost of coal per kilowatt-hour	4.5 mills
Average pounds of coal per kilowatt-hour	4.08 mills

We note that during the year from 1906 to 1907 the turbines averaged to carry 16.8 per cent. of the load.

Comparing the conditions during the year 1906 with the two turbines in operation, carrying but 16.8 per cent. of the total load, with the year 1904 before the turbines were installed, we find that the station delivered an increased average amount of power to the extent of 19.5 per cent., or 482,500 kilowatt-hours per month, and that the total cost of the station output for the year 1904 with the engines was $216,810, while the total cost for the year 1906 with engines and turbines delivering 5,790,000 kilowatt-hours more than were delivered in 1904 was $214,004.70, or that it cost $2805.30 per year less to deliver 19.5 per cent. more energy incident to the low-pressure turbine installations.

A careful consideration of the foregoing figures evidences that the good judgment of the purchaser is borne out by facts and can be duplicated in any power plant under similar conditions.

Scranton Street-railway Plant

The Scranton, Penn., street-railway system was equipped with four simple non-condensing Corliss engines, operated at an initial pressure of 115 pounds, as follows: No. 1 Allis, 42x54, at 97 revolutions, 1400 rated horsepower, 1000 kilowatts; No. 2 Dickson, 26x48, at 80 revolutions, 400 rated horsepower, 300 kilowatts; No. 3 Cooper, 26x48, at 80 revolutions, 400 rated horsepower, 300 kilowatts; No. 4 Cooper, 30x38, at 97 revolutions, 750 rated horsepower, 500 kilowatts; or a total of 2950 rated horsepower and 2100 kilowatts.

The average output of this plant is 1500 kilowatts, while the maximum requirements, of short duration, taxed the entire plant to its utmost. The exhaust of these four engines led into a common tee, from the top side of which emerges a 30-inch free outlet to the atmosphere.

Early in 1906 a 500-kilowatt Curtis low-pressure turbine was installed, taking steam through a 14-inch pipe connected to the 30-inch outlet, and exhausting through a condenser supplied with cooling water brought from the Lackawanna river, a distance of 450 feet, with a lift of 54 feet to the condenser head, at mean hight of the river.

The turbine, therefore, works between the atmospheric pressure and 28-inch vacuum at a water rate of about 38 pounds per kilowatt-hour, or less than 20,000 pounds of steam per hour at its full-rated capacity, while the engines, aggregating about 3000 horsepower, will, at 30 pounds per horsepower, exhaust, when working at their rated capacity, 90,000 pounds in the same time.

There is here, therefore, an excellent opportunity for the installation of at least two or three similar low-pressure units as soon as the load conditions warrant further increase. The method of using the turbine output is similar to the case previously mentioned.

There is a plant in East St. Louis in which is installed an 800-kilowatt low-pressure turbine equipped with a 500-volt, direct-current generator, which is used in multiple with the engines from which the turbines receive their steam. This equipment is utilized for operating the railroad. There is also installed in this station a 1000-kilowatt low-pressure turbine equipped with an alternating-current generator taking steam from the same exhaust header and delivering its output for an entirely different purpose, that is, the operation of lights and stationary power throughout the district.

In closing, readers should be cautioned not to entertain a wrong impression of the idea intended to be conveyed; that is, I feel that the turbine is entitled to first consideration in a new installation, but where an increase is necessary to an existing reciprocating plant, the low-pressure turbine can often be used to better advantage than any other piece of apparatus, without entailing increase in boiler plant or buildings proportionate to the increase in capacity, and in many cases without any increase of the items mentioned.

A Storiette with Some Practical Pointers

Herman was one of those men who never get "rackled," never has any mishap on his "trick," and is always on his feet to see everything. He was about forty-five, heavy set, with dark hair and of dark complexion, a thorough mechanic, having been born of parents naturally of a mechanical turn of mind and from his earliest boyhood constantly amongst machinery. He had served his apprenticeship in one of the shops of Europe and unfortunately had come to the United States during the depression of 1896-7. Not being able to speak English fluently and naturally of a quiet and retiring manner, he did not secure a situation on arrival, in fact not a steady position until some months afterward, but during this time he worked whenever and wherever he could, a few days here and a few days there, and in some unaccountable way drifted to the middle States.

Herman asked everywhere for work in his line, or any line, and finally secured work piling staves in a stave factory at the glorious price of eighty cents a thousand; snow, rain, shine or blow, it was all the same. On a very favorable day when all went well, Herman could pile fifteen hundred to sixteen hundred staves, as they had to be piled to suit his boss and get the price, and then his boss only paid once a month, and at that two weeks after the pay was due, so Herman was never spoiled by having too much ready cash in his pocket. Herman's real opportunity came to him in that miserable stave mill, at least it began there, and you may take my word for it that he is filling a want and filling it well, and rising. It so happened that a particularly dilapidated and broken-down slide-valve engine, used to "pull" this mill, was under the care of a green boy. The engine would often cause unexpected shutdowns. One day the boy was taken sick with a severe cold on his chest and Herman was put firing. He said nothing, but adjusted the engine a little at the noon hour. A week later he had refitted the valve and seat with file and scraper. Two weeks later, when the boy came back to work, the engine was running ten hours a day, the firing was easy, there was no difficulty in holding the pressure up and there were cords of slabs for sale not needed for the firing. Herman was now put on a daily wage basis and told to watch the engine.

A little later Herman was employed on and off in the local machine shop, the stave mill having shut down, and so he went all over the country "fixing" pumps, boilers and engines besides many other kinds of machinery. Herman was good anywhere and seemed a century ahead of anybody else thereabouts on engines, often running the big 12x20-inch at the furniture factory.

It was not a great while before an electric-light plant was put in at, let us call it, Mountainville, because that was not the exact name of the place. Herman was made first assistant and soon after became chief. In this plant were two engines, a high-speed automatic with two belt wheels, or flywheels, in one of which was a conglomeration of springs, bolts, levers, weights and I guess all the other things mechanical known to professionals well versed along these lines, and having as the crown of glory a so-called balanced valve. The other was a Corliss cross-compound, a pretty good little engine, driving four dynamos by direct belting from a flywheel, and of course mostly used for evening service.

One of the things that Herman did that impressed his ability and value as a man and an engineer upon my mind in such a way that I shall never forget it, occurred just by chance; it happened this way: One of the wealthy gentlemen who owned considerable stock in the Mountainville Electric Light, Heat and Power Company owned a flour mill, perhaps a hundred miles from Mountainville, and had been having much trouble with that power plant and had sent Herman down there several times, for while Mr. Smith, the manager of the electric-light company, never seemed to like to have Herman away on such trips, yet he never seemed to know how to evade the wishes of this stockholder. So Herman had been sent down on one of these trips Thursday morning and hoped to be back that night, but the matter could not be put in order in such a short time and Herman telephoned Friday that he could not even complete it that day, so he was told to stay over. Friday night the Corliss got to pounding very hard, the automatic would not carry the load, and the assistant on duty was much perplexed. He did all that anyone there could suggest. He put all the load on the automatic that it would carry, just all it could pull and hold up to speed, but still the Corliss pounded and it seemed as though it pounded harder each minute. Finally the assistant "cut out" the street lights and shut the Corliss engine down, looked it all over and tried every nut and bolt about it. Then he tried the engine slowly. Still it pounded, and again it was stopped and gone over with wrenches and torches and electric lights. When it was started it seemed to pound only a little, not badly enough to endanger any part, but the load had by this time so decreased that the small automatic could pull it, including the street lights, so it was left on for the night.

The next morning the assistant expected Herman back, and feeling considerable chagrin at the difficulty with the engine, went to work early on the Corliss and tried to follow in detail all the advice and suggestions that had been made to him the evening before, as well as all he could think of himself. By 3 o'clock that afternoon almost all the movable parts of that cross-compound Corliss lay scattered about that engine-room floor, and the worst of it was that the cause of the pound had not been found. Suddenly the assistant noticed the time; the Corliss ought to be put on the load at the latest by 5 o'clock and kept on until about 12 that night, as it was Saturday, when all the stores remained open late, and there were street displays, too, and the holiday season near. So he hastened to put that Corliss together in record-breaking time. Perhaps about half an hour had passed in this hurry when the little automatic commenced to bang its valve, and it banged hard, too. I don't think I ever heard it hammer so, and nothing that the assistant could do would stop it. Partially closing the throttle, pumping in oil, slowing down for a moment and then running up to speed had no effect. It continued to pound. Well do I remember Mr. Smith's expression to the assistant as he opened the engine-room door: "My God, are you going to wreck that engine?" He had seen the lights go down when the engineer tried to stop the valve slamming by slowing down for a moment and then speeding up again. Smith looked around the Corliss, muttered a little, said that something must be done at once to save the automatic, and that he was going for a buggy to the railroad depot that he might get Herman over to the power station in no time. Just then the fireman came in and said that the steam was down to sixty pounds and falling in spite of all he could do with two boilers. A glance around the station told the same story in a slightly different way. The banging automatic was slowing down, the lights were getting dim, the telephone was ringing constantly, and ringing in earnest, too, but no one had time to think of that. You could barely read the clock, 4:15.

The excitement that followed can be better imagined than described. Even the boiler-feed pump refused to work. It had been repacked in the water end about a week before, and when the steam ran down to about 60 pounds the friction of the square rubber packing in the water end and the work required to feed the boilers was more than the steam end could supply, so only a few minutes passed after Smith left before the fireman ran out to fire and see that all was right in the boiler room, when he ran back even faster to inform the assistant that he had allowed the water to gradually work down to one gage in both the boilers in his effort to hold the pressure up, and now the feed pump would not put a pint into either.

It lacked but a few minutes to five when Herman rushed into the station, closely followed by Smith and the young electrician who had come direct from a college of electrical engineering. Smith shouted as they entered that all hung on Herman, and some very emphatic expressions relating to his hopes that Herman would get things running "damn quick." Herman seemed to take in the whole situation at one glance; he walked round the Corliss, spoke an encouraging word to the assistant, asked Smith to help him in lifting some of the parts to place, took the fireman with him into the boiler room and immediately sent two men that had been unloading coal into the engine room to help the assistant, telling them that he would pay them twenty-five cents an hour. Then he came back, stopped the automatic engine; the lamps were barely red. The fireman and another man that had wandered in were now working like demons to make hot fires under the boilers, and Herman silenced the telephone by disconnecting one of the wires.

Every man was working, every man had a wrench, and he was using it, too, tightening the cylinder-head nuts and others. The assistant seemed to get through first and stepped out from between the cylinders wet with perspiration. Herman touched his arm and took him to the fire room and told him and the fireman to "holler" when they saw water at one gage, and again at two gages in boilers Nos. 1 and 2, and he passed behind them. It seemed as if by magic at his silent command that water rose, first in No. 1, to one then to two gages, and the same in No. 2. He had passed part of a superabundance of water from boiler No. 3, which was lately cleaned, through the blowoff pipes into the other two.

The steam gages now showed 85 pounds and were rising, the Corliss engine had been pulled over by hand on the belt, the oil cups started and all looked ready, but how deceiving. As Herman stepped up to one cylinder and the assistant to the other, the latter told Herman that in taking the engine down he had turned the eccentrics on the shaft to get the straps and rods down easier, and to get the valve gear down he had unscrewed all the reach rods out of their brass heads, and not finding any cause for the pounding in these places, had put them back again and had put the valve covers on without setting the valves. In the excitement and haste he had overlooked it. It was six minutes to five, steam rising at two pounds a minute, and nearly dark—not a light in the town.

All eyes were on Herman, and by this time many of the good citizens of Mountainville were there. Herman gave a few very brief directions to the assistant, who then put the high-pressure crank on the dead center as near as he could estimate it by the appearance of the connecting rod across the end of the shaft and with the help of the other men, then stood by the eccentrics of that cylinder. Herman took from a drawer in a small table a

catalog of that make of Corliss engine in which were neatly pasted two indicator cards taken from it, on which were many little measurements which he scanned with care but hastily, stepped to the cylinder and adjusted the radial or valve rods, directed the assistant how to move the eccentrics, and I would feel very safe in betting that in less than two minutes from the time he stepped to the cylinder he called, "All right, make fast; put the low-pressure crank on the dead center." In about two minutes more everything was ready for his "all right, make fast and stand clear," and she moved, she rolled over, then another turn, it was surely gaining speed every instant. He cautioned the fireman to watch the boilers very closely, the electrician to be ready to switch on the circuits and the assistant to watch the oil cups, "and give it plenty everywhere."

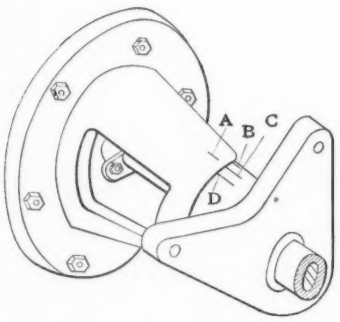
When the electric lights shone forth, I thought brighter than I had ever seen them before in that plant, I looked at the clock. I remember it clearly, only two minutes past five; was it possible? I looked again. It was true. In eight minutes the valves had been set on a cross-compound Corliss engine, four eccentrics set and the engine put on the load. It ran nicely, too; not a pound anywhere, only a little slack on the crank pins. The boiler pump now ran well. It was easy to hold the steam up. What a magical change in twenty minutes. How was it done? Yes, that is what puzzled me, although used to machinery. Still I asked myself "how was it done," how had Herman adjusted those eight rods and four eccentrics almost in the dark?

Later that evening I dropped into the station; the Corliss was still on, running nicely; not a hot bearing anywhere, only a little loose on the crank pins; even the oil supply cut down to normal. In fact, everything about the plant was running as nicely as it ever did. I thought, what a magician Herman is; did all men called Herman have such miraculous powers?

A few days ago I dropped into the station, in fact spent several hours with Herman that evening, and this eventful day came up in conversation and he told me all about it. How simple! I doubt if it will even interest you, dear reader. However, it shows what a man Herman is. It saved the Mountainville Electric Light, Heat and Power Company unestimated money that day. You and I should know it and apply the principle in whatever walk of life we may be traveling.

The builders of that Corliss engine had sent a catalog with it, together with the installation plan and a few brief directions, all of which Herman kept carefully together in a large, strong envelop for ready reference. When the engine was adjusted by the expert and the cards showing the final valve setting were taken, he had pasted one from each cylinder in that catalog in that place in the catalog showing that particular style of engine, and the next day before any adjustment had been changed, he carefully noted on each of these cards, in ink, the length of the rod, the lead with the engine on the dead center and the lap of each valve with the wristplate central. Then he had made a very light, neat chisel mark on each valve bracket and three other fine chisel marks on the valve double arm, or in case of the exhaust, the valve lever, in such a manner that when one of these lines coincided with the one on the bracket, the valve had the most lap. The next showed when the valve and port were line and line, and the other indicated the limit of opening travel.

Thus, on that eventful night he was able to quickly adjust the valve rods to their proper lengths, and knowing the lead with the engine on its dead center, by these same marks he could tell when the assistant had turned the eccentric ahead the proper distance. Was it not simple?



WHERE TO MARK BRACKET AND VALVE ARM

These instructions have been put in the shape of a little drawing, in the hope that it may help many of the readers of this paper in a practical way.

The marks should be very neatly made with a fine chisel and a very light hammer, and exactly in the plane of the axis of the valve stem, and to "register" exactly at the proper positions.

First put mark *A* on the bracket in any convenient position, then add mark *B* on the double arm so that it will exactly register with *A* when the wristplate is at the extreme point of its motion that gives the valve the most lap. Then add *C* so as to register exactly with *A* when the double arm has moved so as to place the valve "line and line" with the port. Lastly, add line *D* to register with line *A* when the wristplate is at the other extreme of its travel.

Similar marks to those described may be put on the exhaust-valve bracket and exhaust-valve arm with equal advantage.

In large engines it is occasionally desirable to use two lines on the steam-valve double arm in addition to those described above, namely, one between *C* and *D* near *C*, to show the lead, and another near *D*, to show when the steam port is fully uncovered by the steam valve; but the designing engineer does not recommend these in most cases, as he considers them unnecessary and five lines is likely to be confusing.

It is a good plan to mark against the end of each line with very small steel stamp letters "lap," "line and line," "lead," "full port," or "overtravel," as the case may be.

In conclusion, it should be stated that Herman obtained his idea of thus marking the bonnets, brackets and valve gear from Frederick W. Salmon, of Burlington, Iowa. The Murray Iron Works Company has set this matter forth in detail in one of the special circulars which it issues to its erectors and gives gratuitously to engineers who operate steam plants sold by it.

Firing Cheap Grades of Fuel

By William Kavanagh

It will be admitted that economical firing or use of fuel is an important factor in the generation of electric current for power or lighting purposes. In large stations or isolated plants where sufficient help is employed, the poorest and cheapest grades of fuel can be burned to advantage. The issuing of great volumes of smoke from the chimneys of power plants is an indication that the correct method of burning bituminous coal is not practiced or properly understood. The question then arises, can soft coal be consumed without the formation of smoke? The answer to this question is, practically smokeless results can be realized from the use of soft coal, but in order to obtain this condition the boilers should be operated continuously, sufficient help should be employed, and the firemen must be experts and know exactly how to burn soft coal.

There are five methods employed in the firing of soft coal, and two of these, shown in Figs. 1 and 2, will produce smoke.

Wedge Method of Firing

Fig. 1 is the "wedge" method of firing, the larger end of the wedge being against the bridgewall. The draft entering beneath the bars encounters the heaviest or thickest layer of fuel at the bridgewall, and the air, finding the highest resistance to its passage through the mass of coal at this point, is deflected toward the front or thinnest part of the coal bed, where it finds a free passage. The rapidity with which the air passes through this part of the furnace raises the front portion of the fuel to incandescence, leaving the back portion of the fuel in a condition

to form smoke, and in most cases deceiving the eye of the unskilled fireman.

Pancake Method of Firing

Fig. 2 shows what is called the "pancake" method of firing. Here the coal is carried at apparently the same depth over all of the grate surface. The air finds an unequal resistance, and when smoke is formed it does not pass through a region of sufficiently high temperature to consume it. In general the pancake method of firing soft coal produces smoke on account of the difficulty in keeping the fuel bed level and producing an equal draft through all portions of the furnace,

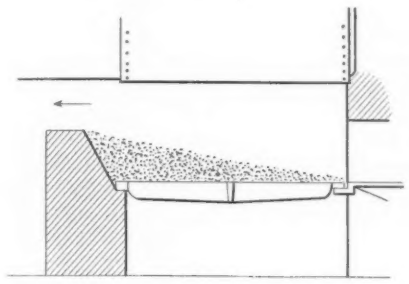


FIG. 1. WEDGE FIRING

and when smoke is once formed, the absence of a high temperature zone permits it to escape to the stack.

Coking Method

Fig. 3 illustrates the coking method of firing in which the fuel is carried in the form of a wedge, the larger end of the wedge lying nearest the furnace door. The resistance offered to the passage of the air in passing through the mass of fuel is least at the bridgewall, so that

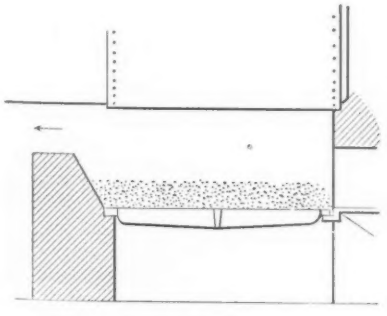


FIG. 2. PANCAKE METHOD

in this region of the furnace a high temperature is maintained and any smoke formed in the heavy mass of fuel must pass through or over the incandescent portion and be consumed

With this style of firing there will be no smoke formed after the furnace is properly in operation. After the front mass of coal is coked, it is pushed back down the incline to the bridgewall and the front is again filled with fresh coal to be coked. In this way a practically smokeless furnace is maintained.

Down-draft System

Fig. 4 shows the Hawley down-draft system of firing soft coal. The air entering through the furnace door is drawn down through the bed of coal. The lower portion of the fuel lying on the grate bars is maintained at a high heat, and any smoke formed in the upper region of the fuel must pass through this highly incandescent bed before it can escape to the stack.

Mixture or Layer Method of Firing

Fig. 5 illustrates the "mixture or layer method of firing soft coal. In this method no smoke will be produced after the furnace is properly charged and in operation. Hence this style of firing is best adapted to plants that continuously operate their boilers. The mixture is formed by using hard-coal dust and soft coal in a proportion suited to give the best results. After a few trials the correct proportions will be ascertained. The rough method employed in the average plant does not tend to hasten the use of this method because of the lack of means properly to mix the dust with the soft coal. One barrow

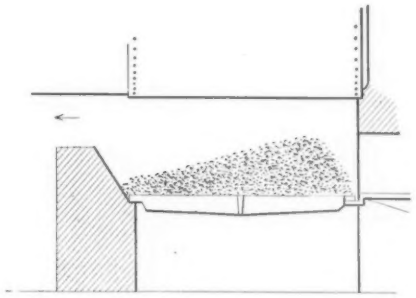


FIG. 3. COKING METHOD

of soft coal to two barrows of dust properly mixed and wet with water will be found to give good results for the coking method of firing. If upon trial it is found the mixture is not rich enough in soft coal, then the quantity of dust should be lessened, say three barrows of dust to two barrows of soft coal. A few experiments along this line will quickly disclose the best proportions to employ, a boiler being set apart or the purpose.

Another Important Method

There is another and very important method of mixture firing in which the hard-coal dust and soft coal are kept apart until fired. This method of firing is as follows: First, the boiler set apart for the trial firing is put in proper condition. Its furnace is cleaned out and a fire of soft-coal lumps is started and built up to a hight of 5 or 6 inches. After this bed is well lighted, cover it with a layer of hard-coal dust about 2 inches thick, the dust being thoroughly wet, and allow the flame to appear on the surface of the dust before covering the dust layer with another spreading of soft coal. After the flame has found its way through this spreading, another layer of hard-coal dust well wet is applied, and in this way the building up of the fire is continued until the furnace is well filled with alternate layers of soft coal and dust, the last layer being dust. In all cases the dust must be wet and mixed after the manner of mortar or cement, and then applied. The thickness of the dust layers should increase as the fire is built up, the last layer of dust being the thickest. After the flame appears on the upper surface of the coal, then the bed should be thoroughly sprinkled with water and the furnace door can be closed. During the day's

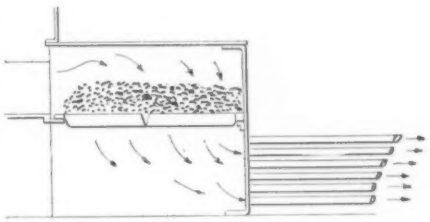


FIG. 4. DOWN-DRAFT SYSTEM

run air holes will make their appearance, and these must be filled in with a shovelful of soft and wet dust. With the exception of an occasional filling in of an air hole, no further firing will be required for a run extending from 10 to 12 hours. If the firing has been properly done, there will be very little ash and clinker to clean out. Occasionally during the day a light sprinkling of water will be found beneficial. This method of firing is different from any other, and as the fireman becomes more expert the quantity of

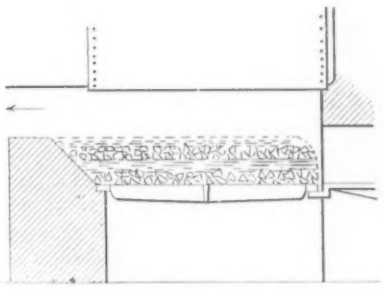


FIG. 5. MIXTURE OR LAYER METHOD

dust can be increased. Cleaning of the fire is the same as with any other soft-coal fire, with the exception of having very little ash and dirt to remove. The proportions by weight found to give the best results are 2½ tons of dust to 1 ton of soft coal. These proportions may vary slightly according to draft, attendance, etc., but with the mixture properly proportioned high economy in the use of fuel will be obtained.

Practical Letters from Practical Men

Don't Bother About the Style, but Write Just What You Think, Know or Want to Know About Your Work, and Help Each Other

WE PAY FOR USEFUL IDEAS

Boiler Room Economy

The able editorial in the September 15 number, on "Boiler Room Economy," merits careful reading by every engineer and power-plant owner. It contains suggestions to which it would be well for owners especially to give some thought, for the majority of engineers give the engine room too much of their time at the expense of the boiler room. Over-estimating the value of savings effected in the engine room and losing sight of the fact that the nearer the coal pile a saving is made the greater that saving, is too common a fault among engineers. Nor is the engineer entirely to blame for poor economy in the boiler room. The owner usually reserves the most worthless and altogether undesirable location possible for the boiler, and too often it is looked upon as a necessary evil, best got along with by denying it the care and attention which are ordinarily given to the least important part of the plant.

As the boiler is bricked up out of sight, and is the dirtiest part of the plant, the engineer is loath to disturb it and get into the soot and dirt which he always meets in making inspections and repairs. Consequently, it is made to work as long as it will, and repairs which another part of the plant would get at once are postponed. Men are not anxious to do work which doesn't show on the outside; that is human nature, and owners as a rule are not looking for places to spend money, but are satisfied if the engine is economical of the steam. They lose sight of the fact that it is better to be a little wasteful of steam economically generated than to be very economical of steam wastefully made.

I know of a plant where a new engine and boiler were recently installed. The engine company had to guarantee a certain steam consumption and a certain speed regulation and the condenser people had to guarantee a certain vacuum, but the owners made no provision to get the hot water back to the boilers; instead, it is turned into the sewer. When the engine was placed, tests were made to verify the guarantee. An oil- and waste-saving machine is installed to get the most possible out of the oil and waste, but the boiler was bought after a trip to a plant where a boiler of that type was used. It was erected at the lowest possible cost and, it seems, with the sole object of saving money. It is located down in a hole, and doesn't even boast a rocking grate.

GEORGE G. BENNETT.

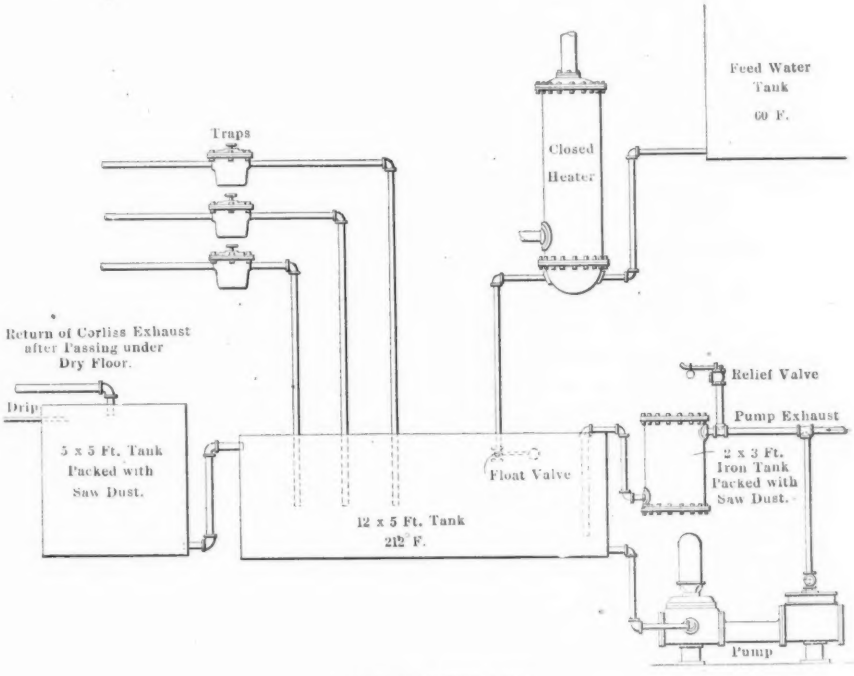
Urbana, Ill.

Utilizing the Drips

When I took my present position, all drips and drains from engines, heaters, driers, etc., ran into the sewer. The feed water's initial temperature was 60 degrees Fahrenheit which, after being pumped through a small closed heater, had a temperature of from 100 to 105 degrees Fahrenheit, according to the load on the boilers.

There were one 60-inch by 16-foot and one 36-inch by 12-foot horizontal return-tubular boilers, and twenty-two steam valves had to be opened or closed to cut one boiler in and the other out. The boiler capacity was too small by over one-half, and new machinery requiring additional power was being installed. After it was known to be imperative to procure new boilers, action was delayed until it was a gamble whether the old ones would hold out under hard continual forcing until the new ones could be installed, which were 72-inch by 18-foot horizontal return-tubular boilers with a working pressure of 150 pounds. I had only two steam valves on each boiler to touch instead of the twenty-two.

There were seven live-steam driers with over a mile of 1-inch pipe, the spent steam blowing to waste. I found an old steam trap in the scrap pile, but was told it was no good, as two engineers before me had tried to make it work and failed. I found it in good shape, but the cover had been put on backward, thus covering the steam port. I put it on right and it has been working properly for two years without any attention on my part except to pack the valve stem on the bypass as required.


Feed Water Tank 60 F.
Traps
Closed Heater
Return of Corliss Exhaust after Passing under Dry Floor.
Drip
5 x 5 Ft. Tank Packed with Saw Dust.
Float Valve
12 x 5 Ft. Tank 212 F.
Relief Valve
Pump Exhaust
2 x 3 Ft. Iron Tank Packed with Saw Dust.
Pump

UTILIZING THE DRIPS

An iron tank, 12 feet in diameter and 5 feet deep, of No. 10 or No. 12 iron, had been thrown out of another part of the factory. I set it in the ground so that the top would be lower than all the steam cylinders and built a strong cover of redwood which would not readily rot, and connected the resurrected steam trap to two of the driers with the discharge running nearly to the bottom of the tank, as shown in the illustration, so that in discharging it would heat the water in the tank. The boiler feed pump was placed lower than the tank, as shown. Fresh

water came into the tank through a valve regulated by a float, after passing through a closed heater. The manager, seeing that I was saving him dollars on the fuel bill, was easily persuaded to buy more traps as needed, which were connected up in a manner similar to the first one.

I found another discarded tank 4 feet in diameter and 5 feet deep which I sunk in the ground alongside of the 12 foot-one. In it, several inches from the bottom, a wooden grating covered with ¼-inch wire mesh was placed. I then filled it with shavings from the planing mill across the way, put a cover on it and connected it up as shown. This made a good oil separator for all drips from the engines, exhaust lines, heaters, etc., where there might be oil. It required cleaning only once in six weeks. The temperature of the feed water as it entered the boiler was then 140 degrees Fahrenheit against the previous 100 degrees Fahrenheit.

This saving so apparent, and my importunity after three months' effort, induced the manager to get me a closed iron tank 2 feet in diameter and 3 feet deep of No. 12 iron with flanges on the side, one at the top and one at the bottom. I connected the exhaust line from the boiler feed pumps, fire pump, and oil feed pumps (we burn oil for fuel) to the top flange. I ran a pipe from the bottom to the 12-foot tank, as shown, and put a relief valve on the exhaust line, and, with the exhaust blowing into the large one through this closed tank, which was well packed with sawdust to remove oil, I obtained 212 degrees heat to the feed water which was perfectly free from oil. It is necessary to change the shavings and sawdust every six weeks.

The smaller quantity of water now coming through the closed heater raises its temperature to 140 degrees, although the closed heater is now a needless adjunct.

An additional dry floor 120 feet by 50 feet was recently made necessary. I ran a 6-inch manifold across one end and a 2½-inch manifold across the other with about 4000 feet of 1½-inch pipe between. Drop for drainage is given each manifold and the 1½-inch pipe. The 6-inch manifold is connected to the 14-inch by 36-inch Corliss engine exhaust which is almost entirely condensed as it flows from the 2½-inch manifold back to the feed pumps as shown.

F. W. Axe.

Tropico, Cal.

Setting of Brushes

I have found that when setting brushes on reversible motors such as are used for elevator or crane service, better results are obtained by setting the brushes as shown in Fig. 1, than by following the usual method. Note that the proper backward lead is given the brush on the hoisting motion, while on the lowering motion the lead is negative or forward. As the current consumed on this motion is slight there is no sparking, and the brown-colored commutator so much desired is obtained.

I also find that when motors run in dusty places, this brush setting works successfully, as the dust gathers on the forward side of the brushes thus making a well-fitting brush, and prevents the jumping and chattering so common in all types of direct-current motors. This position of brushes also works successfully on generators, and while the brushes may wear faster, it is cheaper to get a set of brushes once or twice a year than to make commutator repairs. The usual method and approximate angle of brush with commutator are shown in Fig. 2. The method I have followed for several years and found preferable is shown in Fig. 1. This may not meet with the approval of theorists and others, but I find it makes a better running commutator, gives less trouble and repairs, and requires less attention. I also follow this plan for nonreversible motors with the same good results.

H. B. Palmer.

Erie, Penn.

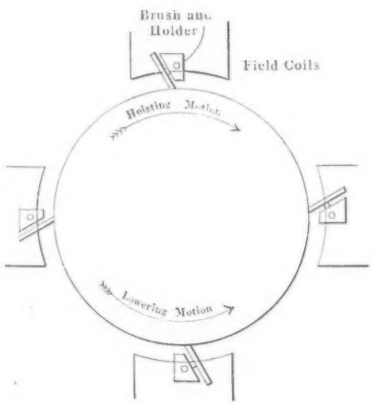


FIG. 1

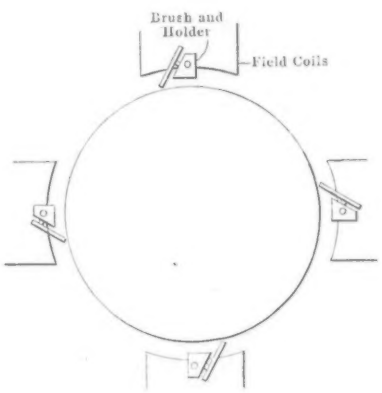
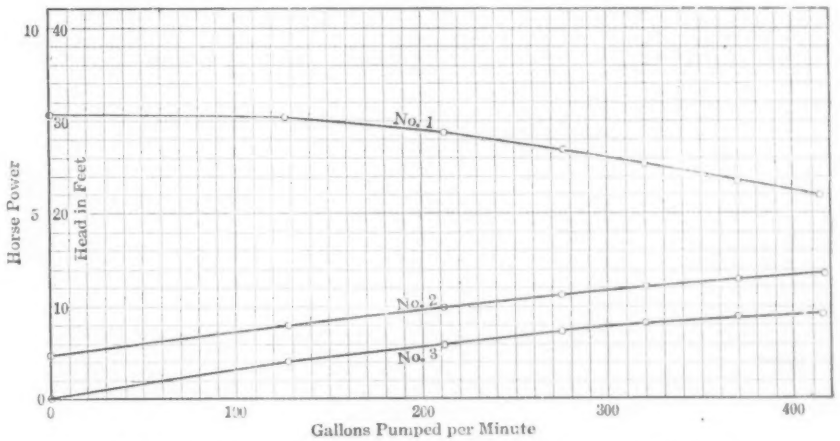


FIG. 2

A Centrifugal Pump Characteristic

Some time ago, L. A. Thompson asked for an explanation of the fact that a centrifugal pump requires more power to operate it when working under a low head, or pressure, than when pumping against a higher head. As he does not say anything about the speed, I take it that it is the same in both cases.



CURVES SHOWING RESULTS OF TESTS OF A 4-INCH CENTRIFUGAL PUMP

The test results of a 4-inch centrifugal pump are graphically shown in the illustration and shows this characteristic of the centrifugal pump very well. Curve No. 1 shows the variation of the quantity of water pumped when the head or pressure is varied. No. 2 is the brake-horsepower curve and shows the variation in the power required when the head is varied. No. 3 is the hydraulic-horsepower curve; that is, it represents the theoretic horsepower of that quantity of water under that pressure. This test was run at constant speed.

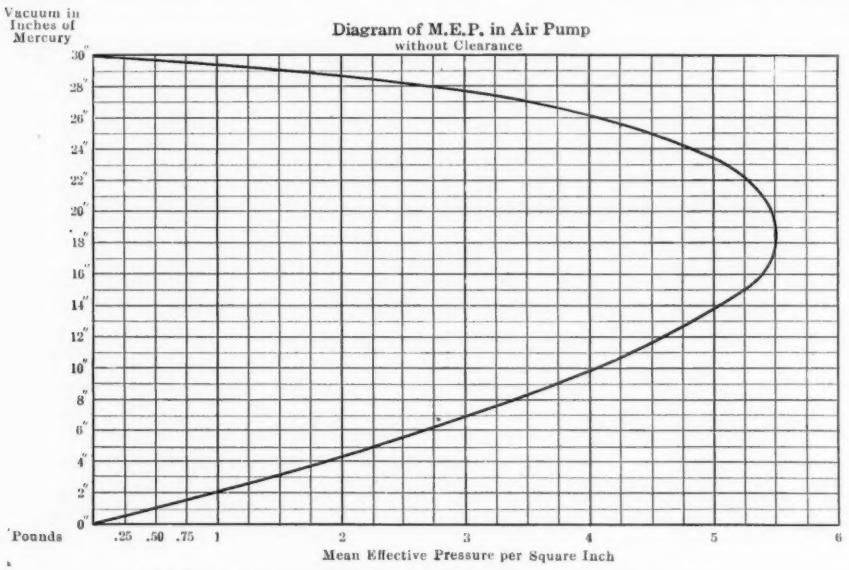
It is seen that as the head against which the pump works is increased, the quantity of water pumped diminishes and at a more rapid rate than the head increases, and consequently the horsepower required is less.

Mr. Thompson says that when the condenser tubes are clean and free from obstructions the gage on the discharge pipe of the pump shows a partial vacuum and the motor takes 65 amperes, but when they become clogged with shells, etc., the gage shows as much as 4 pounds pressure, and the motor uses only 30 amperes.

The reason for this is quite evident from what has been said in regard to the 4-inch pump, which was installed and speeded to run against the head shown when the tubes were clean; and consequently, when the tubes became clogged and the pump had to work against a greater pressure, the quantity of water pumped became less, and naturally the motor used less power.

JOHN B. SPERRY.

Aurora, Ill.



1 INCH OF VACUUM = 5MM.; 1 POUND OF PRESSURE = 4 CM.

Current Consumption of Induction Motors

It seems to me that George H. Kellogg, in his article on page 368 of September 1 issue, is in error when he claims that a centrifugal pump would have less work to do with the discharge closed. He says: "For, when the discharge is closed tight, the only work the pump has to do is to revolve the water contained in the pump casing, and the friction of its bearings."

Surely the power absorbed by a centrifugal pump is due to the resistance the vanes on the rotor have to overcome in revolving, and that this resistance is almost all due to forcing the water against a pressure. Now, when the discharge is closed, the pump quickly builds up to the maximum pressure for the particular speed at which it is rotating and then maintains that pressure until some of the conditions are changed. It is obvious that the vanes are working against this pressure just the same as if they were pumping to their full capacity. It makes no difference whether they are actually forcing water to a hight or just churning it around, so long as they meet with the same resistance they absorb the same power.

The fact that a pump has nothing to do but "to revolve the water contained in the pump casing" in no way implies that it will need less power, as Mr. Kellogg can easily see by turning to page 1025 of the June 30 issue, where there are illustrations and a description of a water brake constructed on the same principle as a centrifugal pump, and where a small one 22 inches in diameter absorbed 2000 horsepower doing nothing but revolving the water contained in the casing. It seems to me that Mr. Kellogg will have to look deeper for the explanation, or else give some more definite proof of his statement.

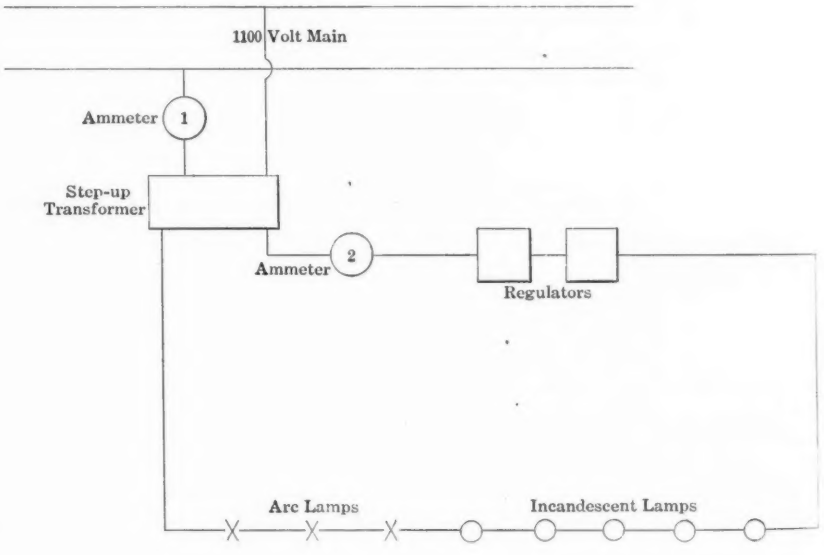
In reference to the air pump, I would say that the cause of the decrease in power required to run the pump at the higher vacuum is most probably due to the fact that the mean effective pressure the pump piston has to work against gets less and less after the vacuum has reached about 19 inches, as will be seen in the diagram which shows the mean effective pressure the piston of a double-acting pump works against in producing the vacuum, neglecting clearance and assuming that the capacity of the tank from which the pump is exhausting is large compared with the piston displacement so that the pressure drop is very small per stroke. It will be noticed that as the vacuum nears 30 inches, the amount of work required to continue the exhaustion is very slight and, in fact, would ultimately become zero at complete vacuum.

GEORGE P. PEARCE.

Exeter, N. H.

Series Circuit Supplied from Constant Potential Circuit

A few days ago I overheard a discussion between two electricians concerning the apparatus shown in the accompanying diagram. The series lights (10 arcs and about 80 incandescents) are operated from the main line by using a step-up transformer and two regulators in series. Ordinary 56-watt carbon-filament lamps have been in use, taking about 20 amperes on ammeter No. 1; ammeter No. 2 registers the current in the series circuit. Now by using 50-watt tungsten lamps, will the reading on ammeter No. 1 be decreased or not? The wattage of the series circuit will certainly be decreased and it seems to me there should be a corresponding decrease in the wattage supplied to the apparatus, and as the primary voltage is constant the current must decrease.



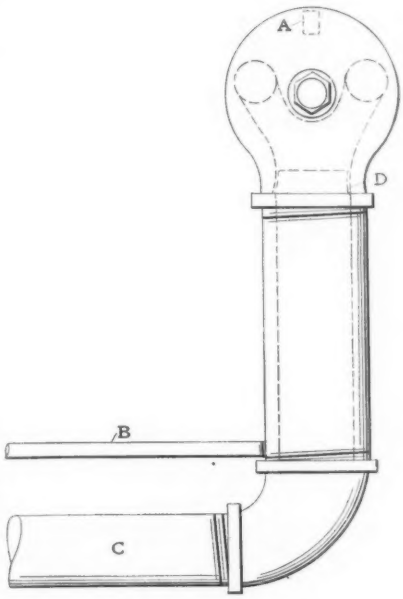
MR. GROVE'S WIRING DIAGRAM

D. M. GROVE.

Covington, Va.

Peculiar Gasolene Engine Experience

I recently had a rather peculiar experience with a gasolene engine. I was running a yacht which was equipped with a pair of 25-horsepower standard engines. We started on a trip of about 300 miles,



THE EXHAUST PIPE

and had covered about 50 miles when the starboard engine began to show symptoms of being indisposed, and its condition grew steadily worse until only two of the four cylinders were doing business, and the speed had fallen from 370 to 300 revolutions per minute.

All indications pointed to the gasket under the cylinder head being gone between the two forward cylinders, and at the first stop the cylinder head was removed and the gasket renewed, although it did not look very bad. However, this did not improve matters any and some further time was spent on the engine without accomplishing anything, but as it was desirous to be moving along, we postponed operations until the next port was made.

By this time I had discovered that the exhaust pipe needed attention. The sketch represents the exhaust pipe from the two forward cylinders. The dotted lines represent the boundaries of the exhaust passages, and the spaces between the dotted lines and solid lines represent the water jacket, the cooling water being discharged from the cylinder jackets to the exhaust-pipe jacket at *A*. The small pipe *B* discharges the water from the exhaust-pipe jacket at the point indicated. The pipe *C* connected the forward and after exhaust pipes and was used as an air heater, a sheet-iron jacket being fitted loosely around it, and the air to the carbureter being drawn through the space between.

As will be seen, the exhaust-pipe jacket screws into a cast-iron fitting at each end, and when the upper casting is screwed on, the exhaust pipe enters with a taper and so forms a water-tight joint between the exhaust passage and the water jacket. When I took the pipe down I found that the exhaust passage between the two fittings was filled solid with rock salt. The explanation of this rather surprising state of affairs was found to be in a crack, about 2 inches long, in the outer shell of the joint at *D*. This allowed jacket water to leak slowly into the exhaust pipe, with the result that the water was evaporated and the salt deposited in the pipe, producing a case of stoppage that required a hammer and chisel to relieve. The crack was repaired by filling it with Smooth-On. A new casting was ordered when we got home, but the patched one is still in use.

H. L. Strong.

South Portland, Me.

Engineering Blunders

A certain plant was built for the express purpose of pumping water for a city and generating electricity for lighting purposes. The plant contained two boilers having 353 square inches of tube area for each boiler, and a total of 706 square inches in flue area for both boilers. This would require a stack having an area equal to the interior of the flues, plus 1 per cent., or better still, plus 2.5 per cent.

The stack was 60 feet high, with an opening 26 inches square which gave an area of 676 square inches, which does not equal the combined area of the boiler tubes. The 706 square inches in the boiler tubes, plus 10 per cent., would be approximately 710 square inches, while the stack has 676 square inches, making a shortage in area of 94 square inches, which would more than equal a dozen of the boiler tubes.

The plant was located in a low region, and the efficiency of a stack depends upon the hight it extends above its surroundings.

The small boilers were discarded to make room for two larger ones having 96 tubes 3¼ inches in diameter, and the same stack was used for the boilers. The second engineer passed by this blunder and did not see it. The new boilers have a combined flue area of 1591 square inches, and the little stack had to do the work for these two additional boilers when one boiler had a flue area of 795 square inches alone. Everyone complained that the boiler did not steam, but they ran the boilers until a new stack 42 inches square was built, when one boiler could carry the load under all circumstances. The new stack was 80 feet high, which put it well up above its surroundings, and the increased area gave the proper draft.

The same plant had a large supply of water at a temperature of 60 degrees. In the summer months, when the surrounding temperature was 90 degrees, we operated the compound pump and compound engines noncondensing with a plentiful supply of water within 10 feet of the pump. The plant was operated 15 years in this manner, and the coal used would amount to about $280 per month the year round. Now, a condenser with this temperature of condensing water would, at the lowest estimate or with the worst surrounding conditions, have paid 25 per cent. of the coal bill, or $70 per month.

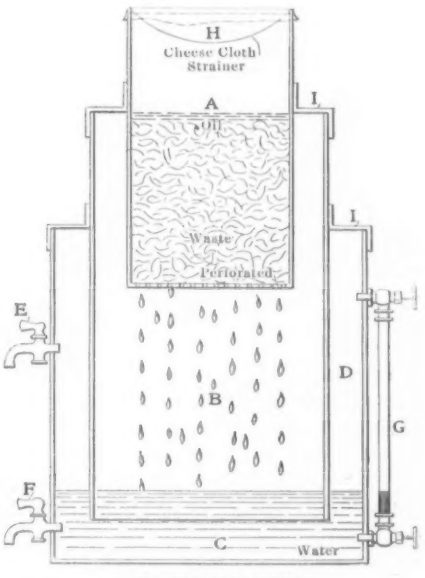
The plant had to be torn down after 15 years' service and rebuilt, but if a condenser had been used during that time, its cost would have been saved many times over.

C. R. McGahey.

Lynchburg, Va.

A Homemade Filter

A few years ago I had charge of a power plant and had quite a lot of oil which had been used, but was dirty. I wished to buy a filter, but was told I could not have one. As there were some empty transformer-oil cans lying around, I made a filter out of 2-, 5- and 10-gallon cans. The sketch shows how it operated. It would filter 6 quarts of oil in 24 hours, leaving the oil as clear and clean as when it came from the dealer.



A HOMEMADE FILTER

The cans were placed one inside the other as shown. The bottom of can *A* was perforated, and two-thirds filled with waste; a cheesecloth strainer was placed at *H*. At *I* lugs were soldered on to hold the cans up to a proper hight. The bottom can was partly filled with water to break up the oil and wash it. At *G* is a gage glass; *F* is a faucet to draw off sedi-

ment, and clean out; *E* is a faucet for clean oil.

I found that 90 per cent. of the dirt was removed by the waste and cheesecloth strainer. The bottom of can *B* was cut out and brought to within 2 inches of the bottom, as at *C*. The weight of the oil in *B* forced the oil through the water into *D*. The cheesecloth strainer and the cans were removable, which made cleaning convenient. A cover was made to go on at *H*.

E. EWING.

Pittsfield, Mass.

Should Change the Position of Compound Feeding Device

In the September 1 issue is an article entitled, "Changing the Position of the Compound Feeding Device," that is somewhat at fault. For instance, the water level in the heater is several feet above the level of the compound feeder and when the exhaust steam is used for heating, there is a pressure of 1½ to 2 pounds on the heating system and, therefore, on the heater, thus making feeding by gravity of the compound impossible. It is also stated that there is "singing of the water." In some cases singing may produce such an effect, but in this case it is the surging of the water, and it can and does produce the effect mentioned with the arrangement of check valves. The singing is due to the fact that there is no air chamber on the suction pipe, and besides, the pump is a single, double-acting one.

R. MCLAREN.

Berlin, Can.

Fuel Saved by the Use of Brains

A few years ago, in one of the New England mills, a new superintendent, bent on economy, discharged the old chief engineer and installed one of the young assistants as chief, but at a smaller salary. The young fellow was an I. C. S. student, bent on making a record for himself.

The plant consisted of a 500-horsepower noncondensing Corliss engine, exhausting through a feed-water heater into the atmosphere in summer and into heating coils against a 5-pound back pressure in winter, a portion of the exhaust going to waste even then. There were six 150-horsepower horizontal return-tubular boilers, with the usual feed-water pumps, traps, heating-system return tank, etc. Feed water was taken from the city mains and a portion from the heating-system return tank in winter. Four boilers would easily take care of the load in summer, but in winter they had to force the six boilers, at times, to keep up the pressure.

In the electric power station in that town there had been installed a belt-driven Edwards vacuum pump with the turbines that replaced an old-style belt-driven generating system. This pump was later replaced with a motor-driven pump of larger size.

Seeing this discarded pump standing beside the power house one day gave the young chief an idea. Being on friendly terms with the station superintendent, he went in and found out from him that the discarded pump was supposed to take care of 1000 horsepower at 13 pounds of steam per horsepower-hour.

Going back to the mill, he measured up the amount of heating coils he had and figured out the number of heat units he would require to heat the mill in the coldest weather. Knowing that his engine took 22 pounds of steam per horsepower-hour when exhausting into the atmosphere and 24½ pounds when working against 5 pounds back pressure, he figured that 17 inches of vacuum would bring his steam consumption down to 18 pounds. Taking his steam table, he figured the amount of heat units he had left in his steam at 17 inches vacuum and found that he would have sufficient heat for his building.

Taking his figures down to the station, he showed them to his friend the superintendent, and asked him if he would lend the old vacuum pump to him for the winter. Thinking it might lead to a good sale, the superintendent readily assented. The young chief soon had the pump installed at the mill beside the return tank, the suction connected up to the heating-system return main and the discharge into the return tank. In his belt line to the pump he put a set of speed-varying cone pulleys so he could run the pump at whatever speed he required. By starting the engine 15 minutes earlier in the morning he was able to get from 15 to 18 inches of vacuum on his heating coils by the time the load came on at 7 o'clock. In the coldest weather he found he could heat the mill all right by carrying 15 inches of vacuum, and in mild weather he could heat it when carrying 26 inches vacuum. All that winter they ran only four boilers and burned 10 per cent. less coal per month than they had in the summer. The fuel bill for that winter was about 65 per cent. of the bill for the corresponding months of the previous winter.

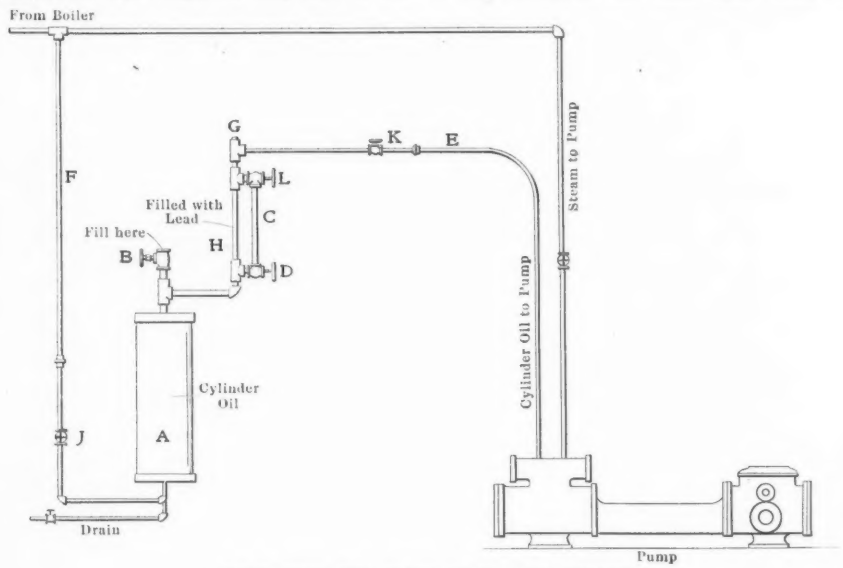
Before the winter was over, the young chief was getting the same salary the old chief had received, and had persuaded the mill superintendent to buy the vacuum pump, drill a well for water, build a cooling tank and install a surface condenser and circulating pump before they were needed in the spring.

G. H. KELLOGG.

Syracuse, N. Y.

Homemade Sight Feed Cup

The illustration shows a homemade sight-feed cup made from pipe fittings. At *A* is a 5-inch pipe, 15 inches long, with a cap screwed on each end, used as an oil reservoir for the cylinder oil. A ½-inch hole in the top is fitted with a nipple and tee. The valve *B* is for filling. Two common gage-glass valves are shown with glass *C* in place. A small cone-shaped nipple is soldered into the bottom with a 1/16-inch hole for oil to come up through in drops, being regulated by the valve *D*. The pipe *E* is made of ⅛-inch stock. At *F* is the water leg made of ½-inch pipe; it should be about 3 feet higher than the top of the reservoirs, and come from the steam main of the pump or engine. The ⅛-inch plug *G* is for the purpose of renewing the water glass or for cleaning it out. The ½-inch pipe *H* is plugged solid with melted lead.



SIGHT-FEED CUP MADE WITH PIPE FITTINGS

The method of operation is first to open valve *J*, then valves *K*, *L* and *D*. To refill the reservoir shut valves *J* and *D*, open the drip pipe and fill through valve *B*.

A. C. WALDRON.

Lynn, Mass.

Concerning Corliss Engines

The Corliss engine is supposed to be pretty well worked out in detail, although we find many errors which should not exist in some of our late designs.

The writer recently had the opportunity of looking over a small Corliss engine of 750-horsepower capacity, supposed to be of the heavy-duty type, and to look at the main frame it had every appearance of a heavy-duty type with some great errors in the design of the small parts, such as the valve gear. The valve gear and governing mechanism are certainly the vital parts of a Corliss engine, but a gear that does not move its valve to a given point cannot be called a good one.

In the ordinary single-eccentric engine we have seven movable bearings, from the throw of the eccentric to the rotary motion of the valve. Should we have 1/100 of an inch play in each joint we would have 7/100, which is a considerable amount of play, and you will find but few that are running closer. This would naturally prevent a good gear from doing the proper work, and with a light, flimsy gear it would be a more serious matter, as there would be the spring of the gear and the lost motion due to the too much play from improper bearings. It is not necessary to have a valve gear over weight, but it is necessary to have the metal properly distributed and the bearings made of the proper length.

In Fig. 1 is shown the wristplate from the modern Corliss engine of 750-horsepower rating. The main bearing of this wristplate is 10 inches long and has a diameter of 24 inches, working under a steam pressure of 125 pounds, thus a considerable strain was brought to bear on the wristplate bearing. As a result the wristplate was soon working as shown by the dotted lines in our Fig. 2, making it quite impossible to keep the small bearings closely adjusted, and consequently causing a poor steam distribution.

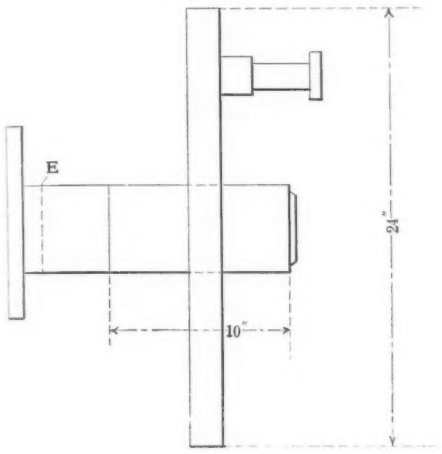


FIG. 1

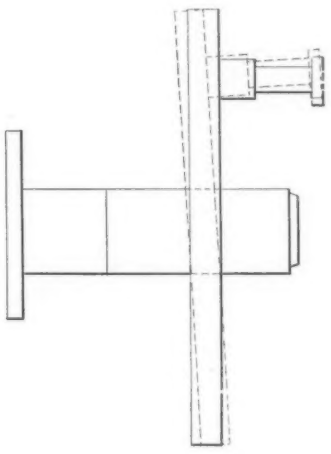


FIG. 2

This bearing could have been made longer by 4 inches at least, which would have made the bearing 14 inches long instead of 10 inches, which would have been much better. This could have been done by extending the hub back to the point *E*, thus increasing the length of the bearing, and at no cost to the builder.

In Fig. 3 is shown a common error in our Corliss engine, especially so of the exhaust-valve bonnet, as at *A*. I have given a dimension that is commonly found on 100- to 150-horsepower engines. This bearing soon becomes worn, and the exhaust valve does not have the proper throw. It would not be a very great additional cost to use a design as shown at *B*, while a better design would be that shown at *C*. This design would tend to keep the gear close to the cylinder and the closer it is kept the less spring there will be.

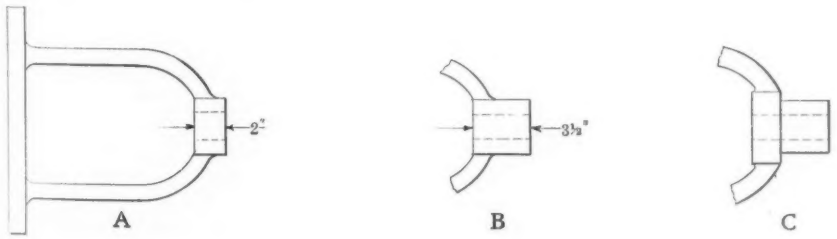


FIG. 3

C. R. McGAHEY.

Lynchburg, Va.

Engine Foundations

In the September 8 issue Mr. Braddon asks for more details on engine erection, and refers to my article which appeared in the July 21 number.

Mr. Braddon must understand that the article only treated the subject generally, as a detailed article would demand a good deal of space. Referring to foundations, I said that 3 feet 6 inches is about the correct depth for a 150-horsepower engine, and for larger engines in proportion. I neglected to give the depth for a large engine, and, of course, without this a true proportion could hardly be taken.

The nature of the ground has always to be considered, as a rocky or good clay ground requires a foundation only 11 feet in depth for a 1000-horsepower engine, while with a loose gravel about 15 feet would be required. The condition of the ground also decides whether it is advisable or not to put in a sand cushion at the bottom of the foundation, as in some large office buildings noises from the engine room are objectionable, and if the ground was rocky and no sand cushion were put in, any hammer or pound in the engine is liable to be transmitted to the steel used in the structure and thence through all the building. In a dry ground the waterproofing, I mentioned in my last article, is not absolutely necessary, and another point is that we do not often see a 1000-horsepower simple engine, as such large units are usually in the form of compound engines and consequently the weight is distributed over a much greater space, so that the depth of foundation is much less than in a simple engine. The reader will notice from the foregoing that the question of foundation depth and manner of construction are determined by the conditions named.

Mr. Braddon also mentions that the hints on regulation are not clear enough. Well, if we hold a tachometer at the end of an engine shaft and the full load is thrown on at once, it will show if the engine drops in speed momentarily and then recovers again, or *vice versa*. I admit that the volts and ammeters are not very good guides as to engine speed, but if the speed at no load and full load is all that is required, an ordinary speed counter will answer. Even with the generator over-compounded or under-compounded, if the governor is not sensitive enough when the load is thrown off, the voltmeter pointer will jump momentarily a few volts higher and then settle back again. However, to be sure that the governor is properly regulated, a tachometer is necessary, and not until the engine is properly regulated can the generator be compounded correctly.

Mr. Braddon does not mention the type of governor on the engine that is giving him trouble through racing. If it is a flywheel governor, the writer would ad-

vise him to look at the fulcrum pin, as sometimes there is a tendency to cut, or possibly the valves stick and work hard, thus pulling hard on the governor, or possibly the latter is not weighted properly.

THOMAS W. HARTLEY.

Massillon, Ohio.

How Heaters Should Be Connected

Replying to F. H. Neely's question on page 365 of the September 1 issue, I believe the way suggested by the consulting engineer will give satisfactory results, which thoroughly justifies the expenditure of the additional initial $1000. Of course, the drips would return to the boiler in the way suggested without any particular trouble, and this is quite a common system in steam heating of buildings; but cooking kettles and warming coils are a different proposition altogether, and unless specially designed and properly connected, will not work satisfactorily.

Suppose, for instance, a large steam kettle is connected up so that the drips drain back direct to the boiler, and that it is 10 feet above the boiler; of this 10 feet, or, say, 5 pounds pressure, tending to return the drips back to the boiler, we can allow 2 pounds to overcome pipe friction, and to open the return check. Then, if the steam pressure is 60 pounds, it is obvious that we must have at least 57 pounds steam pressure on the drips before they can return to the boiler.

If the steam kettle is full of cold liquid, which it is desired to heat, and the live-steam valve is opened wide, we will instantly have a rush of steam into what is a very efficient condenser, and the condensation will be so rapid that the pressure in the kettle jacket will be considerably lower than the line pressure.

I know of a tank which has only three coils of 1-inch brass pipe, the end of which projects through the side and is left quite open, yet 90 pounds of steam passing through an 1¼-inch valve is unable to force even a sign of steam out of the drip, there being merely a small constant stream of warm water running out. The reduced pressure in the steam kettle will be unable to force the water back to the boiler and the drip will "back up" and fill the steam-kettle jacket until it "chokes" the heating surface to such a small amount that it can cause only a drop of 3 pounds in the steam pressure, and after that the drip will return as per schedule, but at the cost of a very greatly reduced heating surface, which will considerably lengthen the time required to heat the liquid; and, as the lower portion of the kettle will be almost cold, the liquid will become heated only at the top, which will make it necessary to have some mechanical agitating device in constant operation. It will thus be seen that although there is steam at 60 pounds pressure, yet for the case taken, only 3 pounds of steam are available, which is not a very practical arrangement.

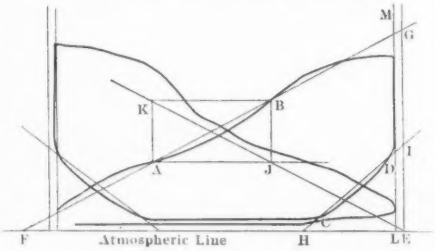
Of course, with steam kettles designed for this purpose, which would have much larger steam spaces and larger admission passages than usual, it may be practical to use this method which undoubtedly has many advantages in its favor. The warming coils spoken of could not be used in the true sense of the word, for they would either have to contain steam at 57 to 60 pounds, or water at any temperature from cool up, which would make regulation very difficult. Of course, there may be conditions in the plant of which Mr. Neely speaks, which would make the direct-return method possible; for instance, if there is a considerable drop between the lowest kettle and the boiler, which would allow a greater variation in the working pressure, and thus a larger heating surface.

GEORGE P. PEARCE.

Exeter, N. H.

Finding Engine Clearance from Indicator Diagrams

I noticed in the September 15 issue that Mr. Weldon, of Fitchburg, Mass., asked Mr. House for a method of finding the clearance of an engine, from the indicator diagrams. For fear that Mr. House may not answer, I submit herewith a card showing two methods for finding the clearance. By these methods I have found the clearance of one of our engines to be ¼ inch, while it actually measures 7/32 inch, so it is seen that for practical purposes the methods give a good approximation.



FOR FINDING ENGINE CLEARANCE FROM DIAGRAMS

The first method is as follows:

Draw any line AB through the expansion curve, or CD through the compression curve; then take the distance from the atmospheric line to the first point of intersection of the line and curve FA and lay it out from B, extending to some point G. Through G draw a line perpendicular to the atmospheric line. The distance between this line EG and the line LM, at the end of the stroke, will give the clearance, measured to the same scale as the length of the card. The same method can be followed on the line HI through the compression curve.

The second method is as follows:

Through any two points AB on the expansion curve, or CD on the compression curve, draw a rectangle with the sides AJ and BK parallel to the atmospheric line; then draw the diagonal KJ and extend to cut the atmospheric line, and erect a perpendicular to the line, and the clearance will be given as with the other method.

I have drawn the two on the same card, to show that they give practically the same result.

JOSEPH H. JACOBUCCI.

Rawlins, Wyo.

Handy Means of Moving Machinery

Probably the handiest means of handling machinery around the power house is on rollers made of old pipe. A good way to propel the load is by means of one or more pipe wrenches, applied to the ends of the rollers.

I recently moved a machine part weighing about six tons up an inclined runway in that manner. It is a far easier method than by using either a tackle or jack.

No originality is claimed, but it occurred to me that possibly it would be new to some of the engineers.

A. G. KNIGHT.

La Salle, Ill.

Broken Packing Rings

I have recently had considerable experience with broken packing rings in the high-pressure piston of a 5000-horsepower cross-compound vertical engine, direct-connected to a 2700-kilowatt generator, used for street-railway work. The packing ring would break in five to seven pieces in two days; sometimes it would last five days. The expense entailed in opening the high-pressure cylinder and the loss of the unit for from six to ten hours had the chief on his mettle. At last the four spare packing rings had been broken and a new one could not be had for twenty-four hours, so the chief hit upon the idea of getting two good halves of the broken ones and fit them to the piston. He fitted two keepers on the ring and put it in place. The engine has now run for five weeks, and absence of pounding, with smooth running, shows that the packing-ring trouble has been remedied.

We also had considerable trouble finding the cause of the pound in a two-stage air compressor. The brasses were keyed on the crank and wristpins; we also let the slippers out pretty snug, but still the pound came at the end of every stroke. We decided to open the cylinders, and on doing so found the piston had 1/16-inch play on the rod. The piston had been forced onto the rod and the end of the rod headed over. We peened the end of

the rod and since then the pound has disappeared.

JOHN MAHONEY.

North Cambridge, Mass.

Evaporation Test with Steam Jets

I have two return-tubular boilers, both of which are equipped with automatic steam jets and air regulators. As I wanted to know if there was any loss by using steam jets I made a test, the result of which is shown in the table. It will be noticed in the report that with the automatic regulation of steam jets and air, which shut off 3½ minutes after fresh fuel had been added to the fire, the cost to evaporate 1000 pounds of feed water at 210 degrees to 80 pounds steam-gage pressure, on the average amounts to 16.4 cents, and on the four days which I did not use the regulator the cost amounted to 19.2 cents, the load on the engine being about the same.

EVAPORATION TEST OF 1000 POUNDS WATER

Date of Test.	No. of Hours.	No. of Gals. of Water Ev. at 212° 80 Pounds at Boiler.	No. of Lbs. of Water Ev. at 212° 80 Pounds at Boiler.	No. of Pounds of Coal Burned $2.85 - Ton.	No. of Lbs. of Water to 1 Lb. of Coal.	Cost to Ev. 1000 Pounds of Water in Cents.	Aut. St. Jets in Use after each Firing.	Not Using Aut. St. Jets.
4-16-08	6	2050	16400	1986	8.2	17.2	3½ Min.	
4-17-08	3	1140	9120	1018	8.9	16	3½ Min.	
4-20-08	5	1600	12800	1623	7.8	18		X
4-21-08	7	2260	18080	2000 635	6.7	19.7		X
4-22-08	6	1820	14560	1725	8.4	16	3½ Min.	
4-23-08	7	1824	14568	1896	7.6	18.5		X
4-24-08	7	1769	14152	2060	6.8	20.7		X
Average Cost with Jets in Use						16.4		
Average Cost without Jets in Use						19.2		

When the fireman was using the automatic regulator, the amount of coal at each firing was six scoop shovels, and very little smoke was seen, and then it was only for one-half minute. When he did not use the regulator, he could only shovel in three to four scoop shovels of coal, and a great deal of smoke was emitted from the chimney, and had it not been that we had asked and secured permission of the smoke inspector to make the test, the firm I am employed by would without doubt have had a few smoke notices mailed them, which they have not had for over 16 years.

Referring to the June 16 issue, in the article of F. W. Hicks, where he states that steam jets often take 10 per cent. of the steam generated, I do not agree with Mr. Hicks. I have successfully used steam jets for over 23 years, and at present have eight jets drilled with No. 12 drill and taper a little to give the steam a spray, so that scale and grit will not stop or clog the jets as easily as otherwise would be the case. A ⅜-inch pipe would be large enough to supply the jets and siphon in the air that is heated by the boiler. The boiler is 66 inches by 18 feet and has a grate area of 27.5 feet. We only use 9/10 of 1 per cent. of the steam generated for steam jets for use on smoke consumers. If we use the full boiler pressure, we would only use on the jets half of the boiler pressure, and that is regulated by the automatic. The boiler pressure is 105 pounds, and the outflow is 2725 feet per second, when the boiler pressure is 60 pounds, the outflow is 2296 feet per second. Even if the steam jets did take 10 per cent. of the steam generated, which I know they do not, would it not be economical to use the jets when the cost of evaporation is less and smoke is prevented?

An engineer told me that eight steam jets with a ⅛-inch hole took all the steam which a 1-inch pipe could supply. Now every engineer knows that if he should make a strainer for a 1-inch pipe, he would have to drill seventy ⅛-inch holes to get the same area tha. the 1-inch pipe has. Some engineers and owners of steam plants are prejudiced against the steam jets, but when they are worked automatically with the fire doors, as I have already explained my device does, they are a good thing for the steam user. The efficiency of the boiler is increased 50 per cent. by using steam jets automatically equipped.

I have noticed in different engineers' textbooks, reports on evaporation tests, where a brick arch was built under the direct heating surface, one-fifth of the heating surface being covered by the arch, and reports of tests made on the same boilers without the arches show that 35 per cent. more water was evaporated in a given time with a given amount of coal. This shows that we cannot afford to hamper the boiler's heating surface with unnecessary obstructions, as they hinder the steam-generating power in the boiler. Personally, I prefer automatic steam jets and air ducts for hand-fired boilers in case the plant is not equipped with stokers.

G. A. GUSTAFSON.

Chicago, Ill.

Trouble with Commutator Brushes

I have two 75-kilowatt generators, direct-connected to two Curtis turbines. About a month ago we turned the commutators down, and since then have been unable to keep the brushes from picking up copper, although the commutators have a good, brown gloss on them. I have used oil and petroleum, and have also run them dry, but with the same results.

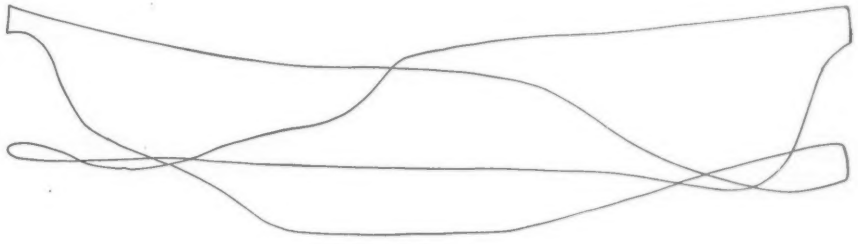
In one station we had three D 62 generators running together for years. One of them began to act badly at the brushes, and the commutator would get very hot. I would like to know why these machines acted so.

EDWARD A. YOUNG.

Isabella, Tenn.

Wants Diagrams Criticized

The accompanying diagrams were taken from the high-pressure cylinder of a quadruple engine. I would like the readers' comments on their faults and their remedies.



DIAGRAMS FROM HIGH-PRESSURE CYLINDER OF A QUADRUPLE ENGINE

The valve is of the piston type and takes steam from the inner edge; the exhaust valves are similar in pattern, but are on the opposite side of the cylinder.

The boiler pressure is 150 pounds. The other three cylinders give fairly good cards and indicate 100 horsepower more than the high-pressure cylinder. The engine is in excellent condition and runs perfectly as far as bearings are concerned, but it is certainly not economical.

F. C. WINTERBURN.

Victoria, B. C.

Surface Condensers

Regarding a recent editorial and Mr. Orrok's article on "Surface Condensers," in the August 11 issue, I would like to make the following statements:

I have never heard that the rate of heat transmission in a condenser is proportional to the cube root of the velocity of the water in the tubes. Experiments of Ser and Hagemann, confirmed by Professor Josse, show that it is approximately proportional to the square root of the velocity.

The results obtained by Professor Weighton in his laboratory tests with a "Contraflo" condenser cannot be applied to practical plants for the following reasons:

He always worked with exceptionally cold circulating water, 40 to 46 degrees Fahrenheit.

His tubes were ⅝ inch outside diameter, only 2½ feet long, and in some cases fitted with triangular lathes to increase the velocity of the circulating water.

He applied a special cold injection to the air pump, the effect of which is credited to the condenser.

In spite of all these provisions, he was not able to double the transference of heat per square foot, per degree difference and per hour, as usually found with condensers of other design.

The high rates of condensation per square foot in these tests are almost exclusively due to the cold circulating water.

As a matter of fact, the "Contraflo" condenser for cooling-tower conditions is not made and not offered with materially smaller surface than other condensers. Therefore, I fail to see much superiority in this type over others.

Nothing in Professor Weighton's tests points to any higher effect due to the compartment system of draining. Such effect could be understood with the small condenser he used for his tests, in which not more than eight tubes are placed on top of each other in each compartment. With the large "Contraflo" condensers, however, the compartments are so large that the draining of the condensed steam is in no way different from other condensers with the usual arrangement of baffles. It must be remembered that in no condenser the condensed water drips from the tubes in the manner imagined, but is rapidly blown away by the steam. This explains why in practice vertical tubes are just as efficient as horizontal ones. Moreover, recent tests of Professor Josse, at Charlottenburg, published in a paper read before the "Schiffbautechnische Gesellschaft," in 1908, show that there is no better transmission of heat with tubes drained in sections. The only gain is a slightly warmer feed water.

The diagram of curves published by Mr. Orrok is more confusing than useful, owing to the experiments being mostly made under conditions not applying to actual condensing apparatus such as steam under atmospheric pressure, stagnating steam, single tubes instead of nests, abnormal dimensions, etc.

The effect of the countercurrent, which has become a regular catchword, is generally overestimated. In the condensing part of a condenser, which mostly forms two-thirds of the total surface, the temperature of the steam remains practically constant, and it does not matter whether a parallel or counter current is applied. Counter current is, however, important in the air-cooling portion, where also the velocity of the steam and air mixture is to be considered. Professor Josse has also proved this lately. The Worthington condenser with a separate air cooler is built on these lines, and allows the condensed steam to be withdrawn at the highest possible temperature, the air being removed by means of efficient dry-vacuum pumps; a very economical arrangement.

Surface efficiency can be much improved by agitating means or deflecting devices for the circulating water, but all these increase the resistance of the flow, and the cost of the condenser, and invariably fail with water forming scale or deposit.

Surface efficiency in all modern condensers is greatly due to the absence of idle corners, or pockets, which soon would fill up with air hanging around the tubes.

Surface efficiency can also be obtained by excessively large air pumps, as is the practice of several European firms. The Parsons "vacuum augmenter" amounts to the same thing. The condensing plant is not much cheapened by this, and the driving power is increased.

In the best modern condensers with induced steam flow, as with very large air pumps or augmenters, not more than 12 pounds per square foot per hour are condensed under turbine and cooling-tower conditions, and in others with small air pumps from seven to nine pounds. Eighteen or 20 pounds is certainly out of question. However, in this respect the condenser has not done worse than the steam boiler. Everything has been, and is being tried, to increase the evaporation per square foot of heating surface, but the fact remains that modern boilers are not of much higher surface efficiency than those of 30 years ago.

OTTO H. MUELLER.

London, England.

Cause of a Hot Crank Pin

In the August 4 issue, page 200, Daniel C. Chittenden claims that stopping the engine above the center and starting it quickly the next morning caused a hot crank pin.

I believe the pin ran dry and was cut the day before, shortly before shutting-down time, due to the oil cup on the stationary stand not being filled in time, and as this probably happened shortly before shutting-down time, the pin and brasses did not get hot enough for the engineer to notice it. The next morning the cup was refilled and turned on shortly before starting time, but as the pin and brasses were cut, the oil did no good.

I have a centrifugal oiler on the crank pin of my engine and the engine is most always stopped above the center, but we have never had any hot pin or trouble because of this, or from starting it too quickly.

H. JAHNKE.

Milwaukee, Wis.

Steel Bands in Place of Leather Belting

Noticing the article on "Steel Bands in Place of Leather Belting," on page 291 of the August 18 number of POWER AND THE ENGINEER, I would say that the German firm in Charlottenburg is several years behind in this respect, if the following paragraph which I quote from an old book is true:

"Mr. John Spiers, of Worcester, Mass., gives us an account of a sheet-iron belt. A lathe used for turning rolling-mill rolls, compound geared, has a 48-inch pulley on it; this is driven by an 18-inch pulley on the countershaft which makes 120 revolutions per minute, and is 8 feet from the 48-inch pulley, measured from center to center. Both pulleys are of iron, smoothly turned on faces. A 7-inch double leather belt was used on these pulleys, but would slip when the turning tool became dull. This belt was replaced by one made of russia iron, such as is used for stovepipes and parlor stoves, and was riveted together in the ordinary way; it was 7 inches wide and 2 inches longer than the leather belt. This extra length made up for the want of elasticity in the iron. During one year's steady run this iron belt could not be slipped, even when a heavy cut on a 25-inch roll was taken, which broke a Sanderson steel tool having a cross-section of 2x2½ inches, a cutting surface of 2½ inches, a feed of ⅛ inch per revolution and an overhang of 4 inches."

I see no objection to iron or steel bands for use instead of leather belts, except that care should be taken to prevent them from rusting; also they should be well

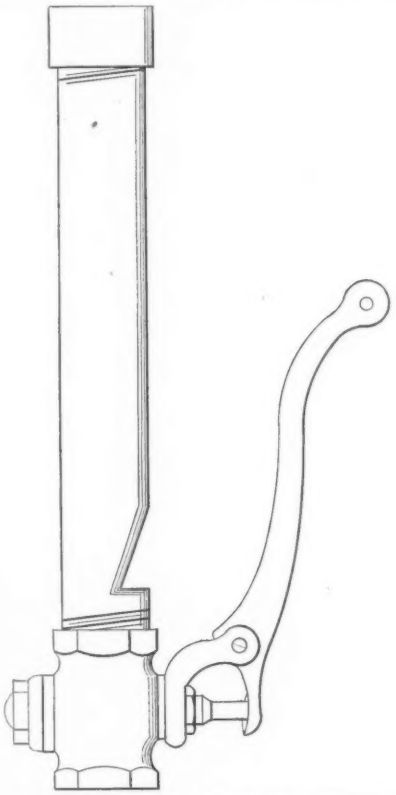
guarded, as, in case of one breaking, the flying strip would be very dangerous to come into contact with.

GEORGE P. PEARCE.

Exeter, N. H.

How to Make a Cheap Whistle

The following describes how a cheap whistle can be made: Take a ¾-inch pipe 8 inches long; cut a thread at



A CHEAP WHISTLE SUCH AS ANYONE CAN MAKE

both ends, and fit a cap on the top end and plug the other end and file a notch in at the side as shown, and screw into a whistle valve. The sound can be made to suit by using a long or short pipe.

FOREST LIBBY.

Everson, Wash.

Cause of a Hot Gasolene Engine

In the issue of September 8, I notice a short article by Ethan Viall, entitled, "Cause of a Hot Gasolene Engine," the engine in question being in an automobile. He states that the trouble was caused by the suction of the circulating pump collapsing the rubber hose connected to it, which, he also states, will occur every time ordinary garden hose is used for this purpose.

The writer has for the last six years been engaged in the automobile-repair business, and will state that in all that time he never found it necessary to use anything on the circulation systems but garden hose, nor has he at any time seen a car, either new or old, with but one exception, which was equipped with regular suction hose, and in the case of that one exception it was not absolutely necessary, but was more in the nature of a safeguard.

The piece of hose referred to by Mr. Viall may have collapsed as he states, but if it did, it should certainly have been easily seen. There is a little trick that garden hose used for this purpose is much given to, which in the writer's opinion was very likely the real cause of the stoppage, and that is the loosening of the rubber lining from the canvas. This rubber lining, not being made to handle hot water, soon swells and rots, peeling away from the fabric of the hose and stopping the passage, either wholly or so nearly so that the suction of the pump will accomplish that result.

If one is careful to change the hose when it begins to show evidence of going to pieces, it is not necessary to buy expensive suction hose for gas-engine circulation systems.

WILLIAM H. RHODES.

Berkeley, Cal.

Gravity Returns

A few weeks ago, upon visiting a friend, I found him working over a steam trap which he said ought to go to the scrap heap. He had been trying to get a new one of a different make, but had failed. He could not depend on it at all; sometimes it would blow all the time, while at other times it would not blow at all, and the pipes would fill up with condensation.

When looking over the piping that the trap was intended to take care of, I found that it was originally fitted up with a reducing valve, which reduced the pressure from 100 pounds to 15 pounds. But finding they could not do their drying quick enough with low pressure, a bypass was put in, which gave the coils in the dry rooms boiler pressure, the returns going to the trap, which discharged into a tank from which it was pumped into the boilers. I told him the trap was entirely unnecessary, since the heating system was under boiler pressure, and that the returns could be carried back to the boiler by gravity, so long as the top of the boiler was below the return pipe. I suggested running the pipe leading to the tank into the end of the feed pipe in front of the boilers, and putting a check valve in the pipe just before it entered the feed pipe. This was a very simple job and we soon had it connected up and working like a charm. In this case, the dry rooms being on the fourth floor of the building, the return pipe had a drop of about 70 feet, or 840 inches, and assuming that it was filled with water about one-fourth of its hight, and allowing 27 inches of water to a pound, there would be approximately 8 pounds more pressure at the bottom of the return pipe than there was in the boiler.

F. P. KINDER.

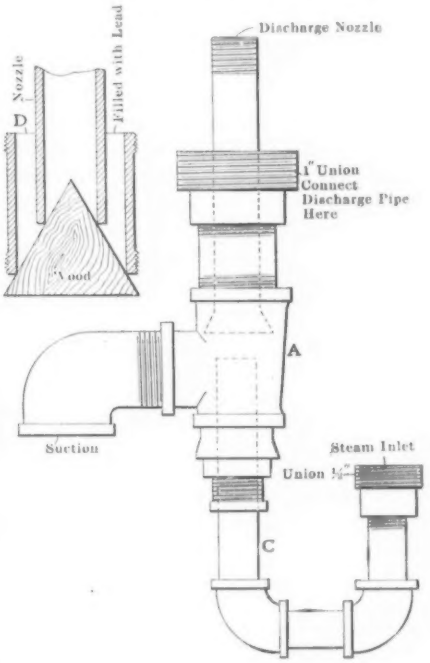
Saxonville, Mass.

A Water Ejector

Following is a description of an ejector made by the writer to remove water from the basement of an oil house. It was made by using a 1-inch tee for the body *A* and 1-inch street ell in the side, to which was attached the suction, which should be as short as possible.

The bottom of the tee was bushed down to ¼ inch, and a ¼x4-inch nipple cut and threaded about 2 inches on one end, as at *C*. Into this was screwed a bushing from the wrong side, which was allowed to extend into the tee to within ½ inch of the other end. This formed the steam nozzle.

A 1-inch close nipple and a ½x4-inch nipple were cut; then a cone was whittled from a block of wood, on which was placed the 1-inch nipple, and next the ½-inch nipple. The space between the nipples was filled with molten lead, as shown at *D*. This formed the delivery nozzle. After removing the wooden plug the



A WATER EJECTOR

rough places were scraped smooth, and this funnel-shaped end was screwed into the upper end of the tee *A*. On the other end of the 1-inch nipple a union was placed and connected to the delivery pipe.

This contrivance cost about one dollar, and would probably be very useful in stations bothered with wet wheel pits or in basements below the sewer level, as was the case with the oil house.

H. J. MCCARTHY.

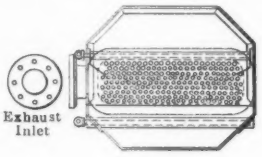
St. Paul, Minn.

The Hornbrook Air Cooled Surface Condenser

A new atmospheric condenser has recently been brought out by the Midland Condenser Company, 1410 First National Bank building, Chicago. It is designed to be of special value in all districts where water is scarce, unfit for boiler feeding, or where the high price of water has formerly prevented plants from running condensing.

moist air at a velocity of approximately 2000 feet per minute. The discharge from the fan passes over the water reservoir, and the excess of moisture in the air is removed by centrifugal force, falling back into the tank to be used again. Different degrees of vacuum are maintained by regulating the speed of the air pump and the exhaust fan. In construction the condenser is light and self-contained and occupies about the same space as the ordinary condenser. A cooling tower is not required for the circulating water.

general view of the experimental plant as installed, the exhaust fan and engine being of the American Blower Company's make, and the air pump of the rotary type. The trials extended over a period of ten days, during which time midsummer atmos-



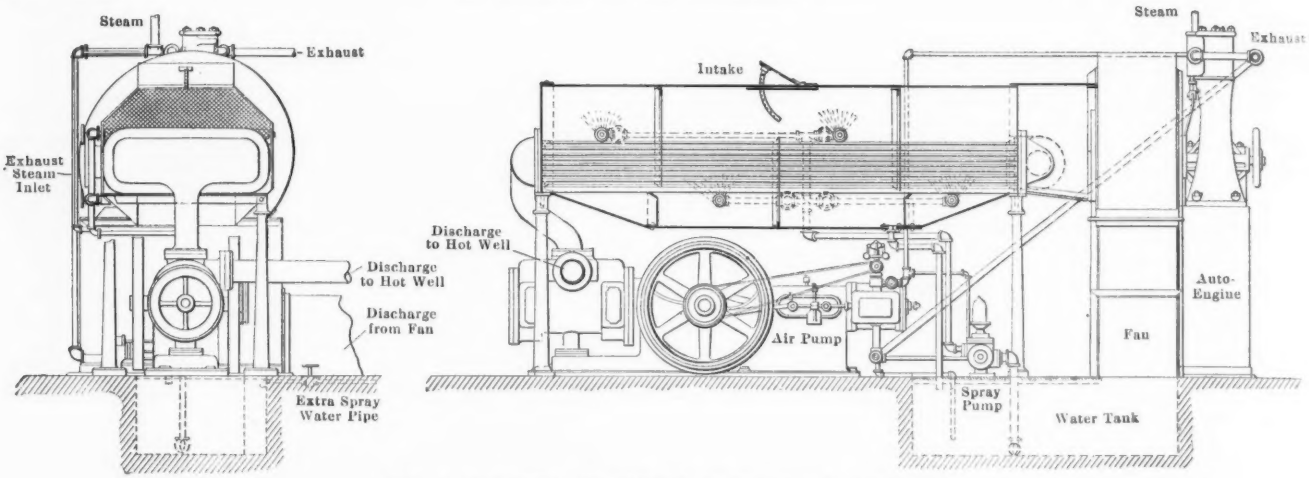


FIG. 1. END VIEW AND SECTION OF HORNBROOK CONDENSER

The condenser consists of a receiver having a tube plate connected to the exhaust pipe of the engine and a similar receiver and tube plate connected to the vacuum pump, with a bank of horizontal condenser tubes between. The whole is surrounded by a light sheet-steel casing, open at one end, the other end being connected to an exhaust fan which draws air through the casing. Spray heads are arranged as shown in the sectional drawing, Fig. 1, with valves on the outside of the casing to regulate the quantity of water flowing onto the tubes. The water drains back into the tank, from which it is again forced through the spray heads by a small pump. Baffle plates are provided as shown, so that the current of air is required to pass four times through the

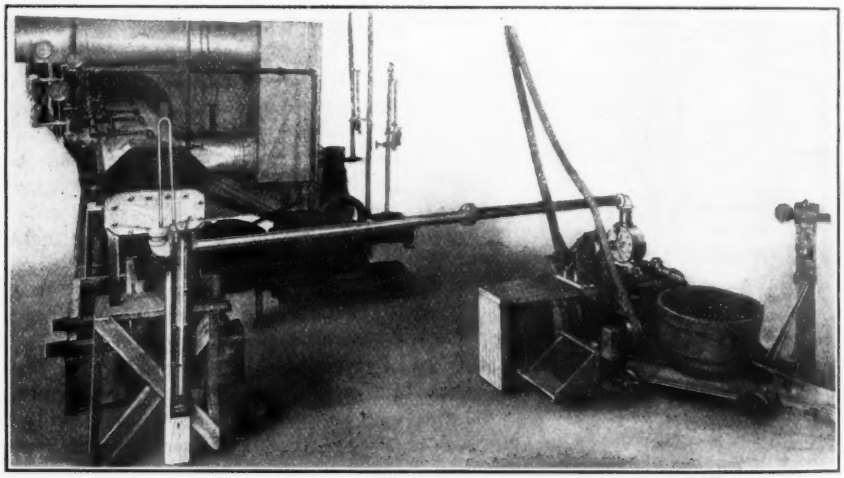


FIG. 2. TESTING HORNBROOK CONDENSER

No.	STEAM.							AIR.					WATER.			AIR PUMP		RESULTS.		
	Pressure of Steam.	Temperatures, Deg. F.			Vacuum by Column Mercury.	Quality of Exhaust Steam.	Degrees Superheat in Exhaust Steam.	Temperatures, Deg. F.				Barometer at Gov. Observatory.	Pounds Per Hour in Circulation.	Pounds Per Hour of Make up Water.	Temperature of Circulating Water.	Pounds of Steam Per Hour Condensed.	Temperature of Water Discharged.	Lb. Water Used Per Lb. Steam Condensed.	Steam Per Sq. Ft. Surface Condensed, Lb.	Moisture in Steam—Per Cent.
		Steam.	Calorimeter.	Vapor in Condenser.				Air in Room.		Air From Condenser.										
								Wet.	Dry.	Wet.	Dry.									
1	5.3	228	135	88.7	28.5	97.5	19	72	84	101	101	29.18	6,000	122	80	302	96	0.4	3	2¼
2	5.3	228	135	111	27.2	97.5	18	71.5	88.3	104	104	29.26	18,000	286	100	455	109	0.63	4.25	2¼
3	5.3	228	135	132	25.1	97.5	19	70	90	106	106	29.18	34,000	337	110	760	118	0.44	7.0	2¼

nest of tubes before being discharged by the fan.

In this condenser air is the condensing medium, water being used only to bring the air to the point of saturation, and the tubes are continually bombarded with this

In a recent series of tests, made in the shops of the American Blower Company, of Detroit, some interesting results were obtained when considered from the standpoint of pounds of cooling water used per unit of steam condensed. Fig. 2 shows a

pheric conditions were encountered, the temperature ranging from 84 to 94 degrees Fahrenheit, and 68 per cent. humidity in the shop. Under these conditions, and holding a vacuum of 28 inches, which is equivalent to 100 degrees Fahren-

heit, there existed a maximum possible difference of only 16 degrees between the open atmosphere and the temperature of the air discharged by the fan after passing through the condenser.

One notable feature of these trials was that the spray or circulating water, although used over and over again for hours, did not rise in temperature to any great degree, but kept always below the temperature of the air discharged by the fan and also below the temperature of the air-pump discharge. For example, with the temperature of the fan discharge at 101 degrees and the air-pump discharge at 96 degrees, the temperature of the circulating water was constant at 80 degrees.

The air measurements were made by a Pitot tube in the discharge pipe and were checked by the use of an anemometer in both the inlet of the condenser and discharge of the fan, which gave direct measurements and checked those obtained with the Pitot tube. The condenser was fitted with four sprays, and tests were run with different numbers in use, the result of which showed that the condenser relies for its efficiency not on the water sprayed over the tubes, but upon the amount of air circulating amongst the tubes.

The steam condensed was taken from the main exhaust of the shop, the supply being regulated by throttling. The amount of steam condensed was determined by weighing the condensation. To determine the quality of the steam, a throttling calorimeter was used. It was found that between the pressure of the exhaust, which was 20 pounds absolute, and the pressure in the condenser, there was sufficient range to measure 3 per cent. of moisture.

The spray water was measured by weir and hook gage, the amount of make-up water being measured in 100-pound lots before emptying into the circulating-water tank. The accompanying table shows the results of three runs at 28.5, 27.2 and 25.1 inches of vacuum, respectively.

Connecting Rod Design

By W. R. Willard

There are to be found on the market many forms of connecting rod, each one designed to comply with certain requirements. The connecting rods for marine work are designed to be as light as possible without sacrificing the strength, while the rods for stationary engines are designed to be well proportioned and to suit the eye, the weight not being such an important factor. If the design looks right, it will, in nearly every case, figure out to be too strong rather than not strong enough. However, the whole design must not be left to the eye. The following design of a connecting rod will give first-class results for stationary engines, and will work very well for marine engines and locomotives.

The rod should be of sufficient strength to withstand the greatest stress to be encountered, with a good factor of safety. It is customary to make the crosshead end of the rod 1.1 times the diameter of the piston rod and the crank end 1.1 times the diameter of the crosshead end. The following formula for steel rods agrees with modern practice:

$$d = \frac{1.1\, D \sqrt{P}}{60}.$$

Here

d = Diameter of the crosshead end of rod,
P = Boiler pressure, and
D = Diameter of the cylinder.

Example—Find the diameter of a connecting rod for an engine with a cylinder 12 inches in diameter and a boiler pressure of 100 pounds per square inch.

$$d = \frac{1.1 \times 12 \times \sqrt{100}}{60} = 2.2 \text{ inches.}$$

The diameter for the crank end of the rod would be

$$1.1 \times 2.2 = 2.42 \text{ inches.}$$

For stationary engines the most usual length of rod, from center to center of the pins, is from 2.5 to 3 times the length of the stroke of the piston in inches. For marine engines it is 2, but is sometimes made as large as 2.5, while for locomotives it varies from 2.7 to 4.8. The rod in Fig. 1 is three times the length of the stroke, which is 12 inches, thus giving a 36-inch rod.

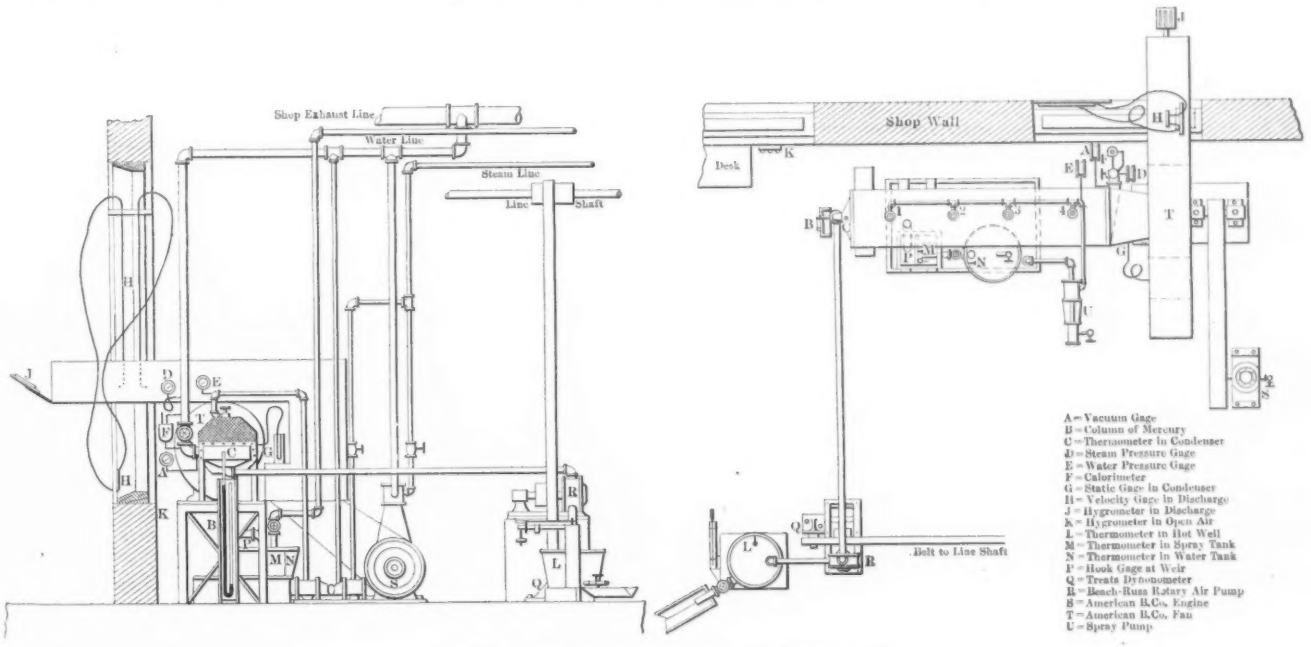

Shop Exhaust Line
Water Line
Steam Line
Line Shaft
Shop Wall
Desk
Belt to Line Shaft
A = Vacuum Gage
B = Column of Mercury
C = Thermometer in Condenser
D = Steam Pressure Gage
E = Water Pressure Gage
F = Calorimeter
G = Static Gage in Condenser
H = Velocity Gage in Discharge
J = Hygrometer in Discharge
K = Hygrometer in Open Air
L = Thermometer in Hot Well
M = Thermometer in Spray Tank
N = Thermometer in Water Tank
P = Hook Gage at Weir
Q = Treats Dynonometer
R = Bench-Russ Rotary Air Pump
S = American B.Co. Engine
T = American B.Co. Fan
U = Spray Pump

FIG. 3. ELEVATION AND PLAN OF TESTING PLANT

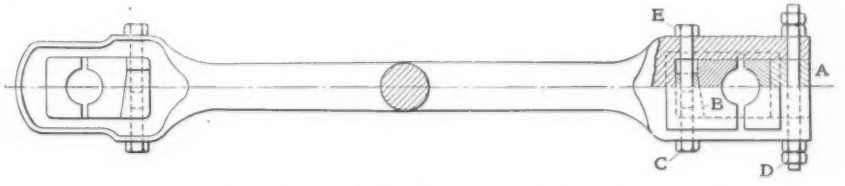


FIG. 1. A SATISFACTORY CONNECTING-ROD DESIGN

The Crosshead Pin

The journal for the crosshead pin is either supported at both ends, or there are two separate end journals, and in either case, assuming the load as equally distributed over the journal, the bending moment is

$$\frac{S\,l}{8}.$$

The moment of resistance to bending is

$$\frac{3.1416}{32} \times d^3 \times f,$$

so that

$$\frac{3.1416}{32}\, d^3\, f = \frac{S\,l}{8},$$

and

$$d = \sqrt[3]{\frac{1.273\ S\,l}{f}}.$$

In these formulas

S = Pull on the connecting rod,
l = Length of the journal and
d = Diameter of the pin.

Letting U represent the pressure per square inch on the journal,

$$U\,d\,l = S,$$

and

$$l = \frac{S}{U\,d},$$

then

$$d = \sqrt[4]{\frac{1.273}{U\,f}} \times \sqrt{S}.$$

Let D represent the diameter of the cylinder and W the maximum pressure of the steam in pounds per square inch. Then,

$$S = 0.8\ D^2\ W,$$

$$d = \frac{0.9\ D\ \sqrt{W}}{\sqrt[4]{U\,f}}.$$

If U = 1200, and f for wrought iron = 5000 and for steel 7000, then for wrought iron

$$d = 0.0182\ D\,W,$$

and for steel

$$d = 0.0167\ D\,W.$$

In practice, however,

$$l = d \text{ to } 1.4\ d,$$

and for good work the following formula should be used:

$$d = n \times D \times \sqrt{W}.$$

If W = 100 pounds per square inch and l = 1.3 d, n will be about 0.0249. This gives as the diameter of the pin in Fig. 1

$$d = 0.0249 \times 12 \times \sqrt{100} = 2.988$$

or practically 3 inches. The length will be:

$$2.988 \times 1.3 = 3.8844$$

or 3⅞ inches.

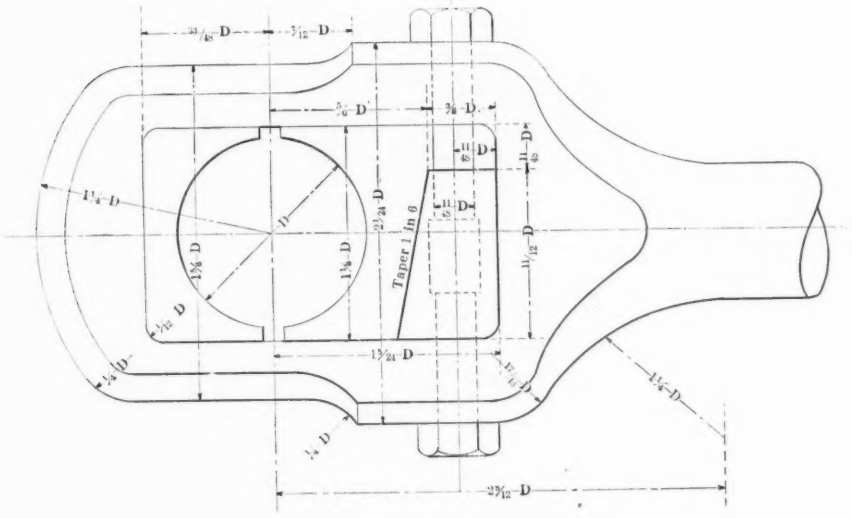


FIG. 2. PROPORTIONS OF CROSSHEAD END

The Crank Pin

Crank pins are designed to avoid heating, for strength and for rigidity. To accomplish these results many formulas have been devised, all of which are fairly reliable. If the pin is made too small, the pressure on the bearing will be too great, and will squeeze the lubricant out, causing the bearing to heat. The following formula for the diameter will give good results:

$$D = 0.034\ \sqrt{P},$$

where P = pressure on the pin. Substituting in the formula, we get as the diameter of the pin,

$$D = 0.034\ \sqrt{12^2 \times 0.7854 \times 100} = 3.614$$

or 3⅝ inches. The length of the pin will vary from 1.2 to 1.5 times the diameter of the pin. Using 1.5, we get as the length

$$1.5 \times 3.614 = 5\tfrac{7}{16} \textit{ inches}.$$

Crosshead and Crank Ends

Fig. 2 shows a crosshead end that will give satisfaction in every respect. The sizes of the parts are marked in terms of the diameter of the pin. This design is well proportioned for any size of rod and will work good on almost any design of engine.

The crank end is made with flanged brasses, and it is, therefore, necessary to have a removable end, as shown at A, Fig. 1. The sizes of the brasses are the same in proportion to the crank pin as the crosshead brasses are to the crosshead pin; the flanges being 0.2 times the diameter of the crank pin in width, and 0.07 times the diameter in thickness. The key or wedge B and the set screws C and E are the same in relation to the crank pin as those of the crosshead are to the crosshead pin. The width of the end is equal to twice the diameter of the pin, and the width of the butt block A is 0.75 times the diameter of the pin, while the diameter of the bolt D is 0.375 times the diameter, and should have a lock nut at both ends, so that it may easily be taken out when in any position.

To tighten the wedge B, loosen the set screw C a little and tighten up the screw E; repeat this operation until the brasses are in the proper position. Always make sure that the set screw C is tight when the wedge is in the proper position.

To replace the brasses remove the bolt D and the butt block A; the brasses can then be slipped out and new ones put in their place. Care must be taken to have them fit snugly against the forks.

Cost of Unanalyzed Indicator Diagrams

By W. N. Polakov

It may seem that the invention and widespread use of the indicator ought to have elevated the steam engineer from the level of a medicine man to that of a scientifically educated doctor of medicine, who applies the stethoscope instead of doing all sorts of fantastic guesswork. This, in fact, is not the case. The modern doctor knows well how to handle his disease-discovering instruments, but a great many steam engineers are absolutely ignorant as yet in the taking and reading of the indicator diagram. Even in large and world-famed mechanical works it is frequently the case that numerous diagram records are taken, but are never figured out, and sometimes not even looked over by the superintendent of the power plant. In other cases neither the engineer nor the power supervisor had any knowledge as to how to handle the indicator, and, of course, the diagrams had no meaning to them except that of a queer thing they were obliged to record

and send to the office merely for filing purposes. There are also cases where the engineer, instead of sending in the actual diagrams to the office, will substitute neatly drawn copies of some old records, some of which may even be from quite another engine. The results of this kind of irrational practice are: (1) The

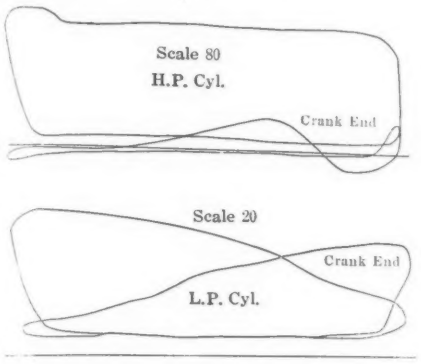


FIG. 1. REPAIRS ARE NECESSARY

engine uses too much steam; (2) the engine does not develop its full power; (3) repairs are made at inopportune times and their costs are extravagant; and (4) failures, accidents and interruptions cannot be foreseen and averted.

In the works of one of the largest locomotive companies in this country the writer had occasion during the last year to see the three ways of "indicating" steam engines, and notice the inevitable results thereof. One of the cases was an engine of the Corliss cross-compound noncondensing type directly connected with a direct-current generator of 1000 kilowatts capacity. Its dimensions were: 30x52x48 inches; revolutions per minute, 100; gage pressure, 150 pounds. An indicator diagram of the engine was taken on December 26, 1907, and is reproduced in Fig. 1.

It was pointed out that immediate repairs were necessary, as evidently the valve stems of the high-pressure cylinder were twisted and the piston rings of the low-pressure cylinder were leaking considerably. Investigation was made, and it turned out that the valve stem of the high-pressure cylinder was indeed twisted

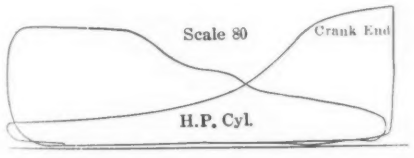


FIG. 4. HIGH-PRESSURE CYLINDER DOING ALL THE WORK

over 15.7 degrees, and the piston rings of the low-pressure cylinder were broken to pieces, and, by the way, the engineer in charge of the engine had not even suspected up to that moment that anything was wrong. After these repairs the engine gave the diagram shown in Fig. 2.

From a comparison of Figs. 1 and 2, it will be seen that in the first case steam was admitted for the full stroke, whereas in the second case the cutoff on each stroke was 33⅓ per cent., resulting in an economy of 33⅓ per cent. of live steam per revolution, or with the same number of revolutions, 100 per minute, in both cases, an economy of 33⅓ per cent. in the total consumption of live steam. Roughly figuring, this saving amounted to 14 pounds of steam per horsepower per hour, or with an average of 10 working hours per day, and assuming 30 days in one month, this economy will equal 4200 pounds per horsepower of water evaporated, and for the full rating of the engine, 4200 tons. With a ratio of evaporation of 1 to 7, this volume of water requires 600 tons of coal at a cost of $2.55 net, and plus handling, conveying, etc., $3 per ton. All circumstances indicate that matters had been in this condition for at least a month before the diagrams were analyzed, and, therefore, the company, through absence of even a superficial analysis of the indicator diagram of this individual engine, had suffered a loss of at least $1800.

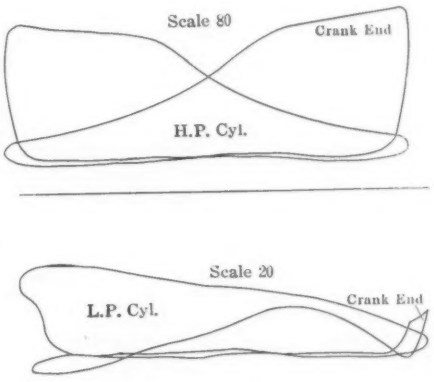


FIG. 3. PIECE OF PISTON RING IN LOW-PRESSURE CYLINDER

On February 4, 1908, a diagram taken from the same engine had the appearance of Fig. 3. Its explanation was, of course, simple; a piece of the piston ring, which had been broken in December, had been caught in one of the ports of the low-pressure cylinder and had evidently twisted the valve axle. It was impossible to cut out the generator operated by this engine and leave the shops without the energy supplied by it, as the repairs would have lasted too long. Therefore, it was decided to disconnect the low-pressure cylinder and let the high-pressure cylinder do the work alone (Fig. 4). If we disregard the bad effects of the one-sided action of the forces on frame, shaft, etc., and direct loss from inefficiency through working the engine by means of the high-pressure cylinder alone, we find that during the 35 days since the last repairs, when the broken piston ring was supposed to have been removed, the twist in the valve stem of the low-pressure cylinder had caused the loss of about 10 per cent., or an overconsumption of 238 tons of coal and a net loss of $714.

The diagrams of Fig. 5 show a case of overloading the same engine about 30 per cent., which was caused by the necessity to stop and repair another engine during work days instead of the

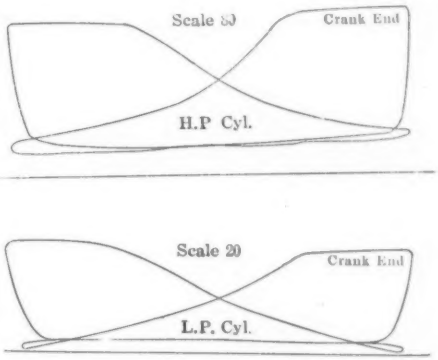


FIG. 2. AFTER MAKING REPAIRS

usual time—Saturday and Sunday. This resulted, of course, in unnecessary expense.

Even the instances enumerated tend to show clearly how detrimental it is to the owners of power plants when their engineers do not know how to use the indicator and how to analyze, scientifically, the indicator diagrams of their engines, but rather regard them as fancy playthings and the office's demand for diagrams a useless waste of their precious time.

It will generally be found that like occurrences are a permanent characteristic of works where engineers still belong to the old type of medicine man, instead of being scientists. Even supposing that only three cases, like the ones quoted, can be avoided each year by putting a specially trained engineer in charge of the power

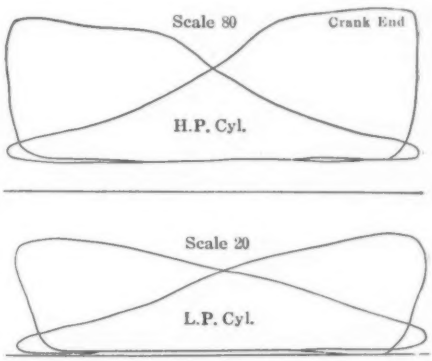


FIG. 5. ENGINE OVERLOADED 30 PER CENT.

plant, the net saving to a given company would be not less than $7500 a year, which is a figure well worth considering. And, besides, it should not be forgotten that losses from the wasteful use of steam in the engines constitute only a small percentage of the total inefficiency of an average power plant.

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Forcing Boilers

Suppose a boiler plant, including housing, piping, accessories, etc., to cost twenty-five dollars per horsepower, and suppose it to be charged twelve per cent. per annum for interest upon the investment, depreciation, taxes, insurance, etc.; there will be a charge per rated horsepower of three dollars per year, whether the boilers do any work or not.

Suppose that when it was running at its rated capacity it took four, and at double its capacity four and one-half, pounds of coal per horsepower-hour. If coal is worth four dollars per ton, or one-fifth of a cent per pound, it will cost one-tenth of a cent. more per hour per horsepower in fuel to run the boiler at twice its rating. If it ran this way three thousand hours per year, it would cost three dollars more per year in fuel, and the case would be equal as between loss of efficiency from overcrowding and increased standing charges by doubling the plant.

The importance of the standing charge increases as the load factor becomes less. It is expensive to buy and install a lot of extra boilers to be used but a fraction of the time on the peak of the load. Such boilers involve not only their standing charge of twelve per cent., or so, but the coal used in keeping them banked during the large part of the time that they are not in service, and the radiation from themselves and the additional piping which they require. It is not to be wondered at, then, that managers of plants with a widely varying load prefer to force boilers upon the peak of the load to putting in a large surplus to be cut in and out. The surprising thing is that the forcing can be carried to such an extent with so little falling away in efficiency.

These considerations have led to considerable modification in power-plant practice. The ratio of heating to grate surface has been cut down, and more coal burned per square foot of grate and of heating surface. At the Interborough (New York) station, Mr. Stott has installed a Roney furnace under each end of a Babcock & Wilcox boiler, as we described some time ago. At the proposed extension of the Delray station of the Detroit Edison Company, combined Stirling boilers with double-side grates will be used. At the Quarry street station of the Chicago Edison Company the ratio of boiler to turbine horsepower will be, it is said, extremely low, confidence in the result being warranted by their experience in the Commonwealth station. Even with steady loads, practice is tending toward a greater evaporation per square foot of heating surface, toward getting more work out of a dollar's worth of boiler, and the limiting factor is not the falling off in efficiency, but the increased cost of furnace and boiler repairs. One may spend more for firebrick and tubes than he would in interest and taxes.

Deceiving the Inspector

In summing up personal traits of character, deception in one form or another has much to do with lowering one's standing. Deception may be practiced in numerous ways, and in many instances men will put themselves out to deceive rather than take a shorter course and be thoroughly honest. Leaving out the question of morals, what does it profit a man if he deceives the whole world and makes a fool of himself? And there are many instances in the engineering world where men have practically done this very thing.

This question is especially applicable to the relation of the inspector toward the engineer, and *vice versa*. The inspector rarely, if ever, deceives the engineer in respect to the condition of the boiler or boilers inspected, but the same cannot always be said of the engineer.

Boiler inspectors do not find their calling ideal by any means. Their work is hot, dirty and disagreeable. They strive to perform honestly their duty of trying to detect weaknesses, defects and dangerous conditions which, if not brought to the attention of the engineer or superintendent, would escape the attention of the attendant, and through neglect become a serious matter. No sensible engineer cares to operate a plant where defects are known to exist, and no sensible engineer will have a hand in concealing defects from the attention of the inspector.

In a great many plants the inspector finds conditions which indicate coöperation on the part of the engineer-in-charge toward a careful and complete inspection of the boiler to be inspected. This consists of having the interior and exterior of the boiler in as clean condition as possible, in order to facilitate inspection work, making it less difficult to detect defects.

There are engineers, however, who do not view this matter in this light, but who look upon the inspector as a necessary evil and a chronic "fault-finder." Such take especial pains to conceal a defect, regardless of its character, and, if the concealment is successfully consummated, delight to boast of their duplicity. Such action is little short of idiotic, and an even stronger term might be used appropriately. The average engineer or fireman has an experience during a lifetime with a few steam plants at most; in fact, in many instances the experience is limited to one plant; and they have become so isolated from engineering progress as to become "back numbers."

The inspector, on the other hand, visits

scores of steam plants yearly, finds all kinds of apparatus and conditions, has new experiences, and is up-to-date in matters pertaining to safe conditions of steam-plant equipment. Having such a fund of practical information to start with, he is in a position to give every engineer who "knows it all" a few pointers still unknown to him. He may not know engine indicators better, but he does know boilers.

Viewing the question from the foregoing standpoint, the engineer or fireman who conceals or attempts to conceal a defect from this one man who can give him sane, intelligent advice stands in his own light and is guilty of an act for which there is no excuse.

Inspectors may not always agree on trivial matters, but when it pertains to conditions which hazard the safety of the steam plant they will stand as a unit. Inspectors may not always be angelic in treatment, nor always courteous and agreeable, but as a general thing they will respond to friendly advances. When the conditions are considered—the number of men they meet and the numerous cases of boilers to be inspected, frequently only half prepared and some so hot that no man should be asked or expected to enter them—one can readily see that the inspector cannot be expected to enter each plant beaming with good nature and ready to swear that you are the best fellow on earth.

The inspector comes, like the doctor, prepared to diagnose the trouble and suggest the remedy, and he should be afforded every facility in making an inspection so that it will be most thorough. The advice he gives should be carefully weighed before denounced as unnecessary. No defects should be concealed from him, but on the contrary the engineer should take him into his confidence and ask his advice and assistance, which will be found forthcoming as freely as a doctor gives his aid to those in need.

Overaccuracy in Power Plant Reports

In making up a report of power-plant operating costs there is often a temptation for the engineer to carry the results farther than is either necessary or consistent. Some reports even exhibit fractions of a kilowatt-hour, when the total output of the station for a year is, perhaps, several million of such units, and in giving the coal consumption, the decimals are carried out to several figures, when there is no possibility of such accuracy in actual practice. In a recent case of this kind the report of the plant's operating costs for the year covered gave the annual consumption of coal as 7315.344 tons, and the average cost per ton to the company was figured at $4.56468. Another company in the same territory reported that its coal consumption for the year was 5875.2174 tons.

It is probable that these ridiculous decimals were calculated by someone in the auditing departments of the companies concerned, for it does not seem possible that an engineer with the proper training would make such a display of the lack of proportion in his mental makeup. It is hardly probable that any commercial company can tell its annual coal consumption within a tenth of a ton, let alone going to the ten-thousandths, and figuring the tonnage in three-ounce lots. Figuring the average cost to the hundred-thousandth of a cent is worse still, and a company displaying such lamentable ignorance of the probabilities of engineering accuracy becomes the laughing stock of intelligent engineers. It would appear to be the plain duty of every engineer to see that, so far as he is able, no such travesties of scientific accuracy shall creep into public reports of his organization and make the figures of its operation ludicrous.

Centrifugal Pumps

With the introduction of the steam turbine as a prime mover, and the manifest necessity for a high degree of vacuum, came the problem of the selection of machinery for the handling of the large quantities of water required for condensation and the maintenance of a low condenser temperature. Besides the question of capacity, there were other factors, such as floor space and head room, cost of operation and repairs, efficiency and reliability.

In the majority of cases the centrifugal pump has been chosen as most nearly fulfilling the exacting demands of modern condenser practice. With possibly one or two exceptions the design of centrifugal pumps has followed closely the principles of construction embodied in the first pump of this type which was put in operation about ninety years ago, and which was known as the "Massachusetts" pump.

While adhering to the fundamental principles of construction, subsequent designers have each striven to eliminate from his own work all of the discernible defects in the product of his predecessors, while retaining their best features and adding new and desirable ones.

In general, the principle upon which the centrifugal acts is a compound one: Partly centrifugal, caused by the rotation of the water by the impellers; and partly radial, as the water travels from the center to the periphery.

This combined radial and centrifugal path which the water travels results in a spiral which leaves the tips of the impeller wings at a tangent with velocity proportional to the speed of the impeller.

There is one apparently paradoxical characteristic of centrifugal-pump operation that excites the interest of the engineer the first time it is noticed. It is, in this running at a constant speed a reduction of the head pumped against will increase the load on the pump. This is due to the fact that the volume of the discharge increases inversely as some function of the square of the head. Hence the work done will increase under a decreased head if the speed remains constant.

Centrifugal pumps are in no sense "air" pumps, and a very small air leak into the suction will render them inoperative. The great variety of service to which this pump is adapted from irrigation to hydraulic presses and the increasing extent of its installation for all classes of pumping work make it imperative that the operative shall be familiar with the fundamental principles governing the operation of this class of machinery.

The fountains of knowledge in this line are not monopolized by any corporation, and any engineer who understands elementary mathematics may become master of all the learning needed for the selection and successful operation of these pumps. Textbooks on the subject are not rare and manufacturers' catalogs containing a store of classified engineering information which may be had for the asking are plentiful, and it behooves the engineer who wishes to demonstrate his usefulness in his chosen vocation to "get wise."

Attend to the Little Things

It is the little things that count in the operation of a steam plant. As the ocean is composed of "little drops of water," so the daily life of the engineer is made up of little duties. If each detail is attended to at the proper time and in the right way, the plant as a whole will be practically perfect in its management and operation.

A very successful engineer, who had won success through a long struggle against what is usually termed "hard luck," once said that his motto had always been: "Whenever you see a head, hit it and hit it hard!" If a slight leak developed, he did not wait for it to grow into annoying proportions, but attended to it immediately; if an engine developed a slight knock, he did not wait for it to develop into a pound, but keyed it immediately. His engines ran well. His pipe flanges were always tight, and the tools he used were in good order.

Instead of being a slave to his work, he was master, and had more time to give to the study of his vocation or to look up batting averages than any engineer of his acquaintance, all because he attended to the little things that needed attention when attention was needed. In steam engineering, as in banking or commerce, "he that is faithful over few things shall be ruler over many things."

Power Plant Machinery and Appliances

Original Descriptions of Power Devices
No Manufacturers' Cuts or Write-ups Used

MUST BE NEW OR INTERESTING

The Conkling Reversing Clutch

There has recently been introduced by the Conkling Company, of Chicago, a reversing mechanism employing a system of gears which has been very favorably commented on by those who have seen it in operation. The reversal of the direction of rotation is accomplished without noise, as the gears are thrown neither in nor out; all gears in the system remaining permanently in mesh. This characteristic makes the device valuable in any place where a reversing action is desired, and more especially in conjunction with individual motor drive, where a shaft connection from the motor to the machine can be made to take the place of the belts, pulleys and idlers generally used. In addition the device embodies a simple and sure method of disengaging the power.

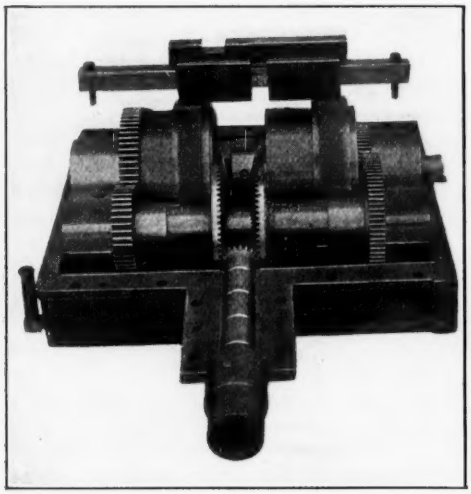


FIG. 1. REVERSING MECHANISM WITH COVER OFF

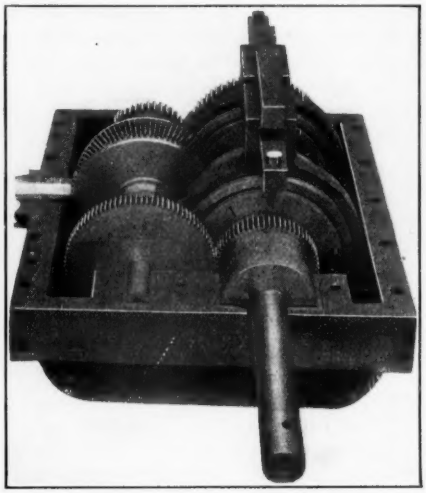


FIG. 2. END VIEW

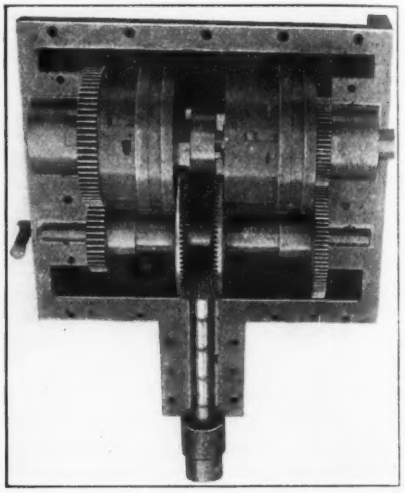


FIG. 3. TOP VIEW

Fig. 1 shows the device with the cover removed. Extending to the right is the driven shaft, while the other containing the four grooves is the driver. The beveled pinion on the end of the latter runs the mechanism on each side of the device in opposite directions. The movement is communicated by means of the spur gears, as shown in Fig. 2, to the two revolving drums on the driven shaft, which it is obvious also moves in opposite directions.

Inside of these drums is located the reversing mechanism. Each drum contains an internal, expanding clutch which may engage its drum and cause the shaft to rotate. Between the drums on the driven shaft, as shown in Fig. 3, is a wedge-actuating collar which can be moved longitudinally on the shaft in either direction and engage either drum. This collar is moved by two movable, bronze, threaded sleeves on the drum shaft, one for each direction of rotation. The yokes, one of which may be seen located over each drum in Fig. 1, actuate two internally extending saddles, or nuts, which engage either threaded sleeve as desired, moving up the wedges and setting the clutch and causing the shaft to rotate in the corresponding direction. Fig. 4 shows the driven shaft with one driving drum removed, exposing the expanding clutch, wedges and movable bronze sleeve.

Assuming that the right-hand clutch is engaged and it is desired to reverse the direction of rotation, the yoke-shifting device is moved, disengaging the internally extending nuts in the right-hand drum and causing the corresponding nuts on the left-hand drum to engage the threaded sleeve on the left, thus screwing the wedges out of the right-hand clutch and expanding the other.

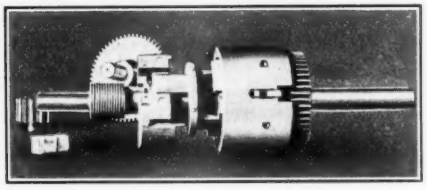


FIG. 4. DRIVING DRUM REMOVED

At the instant the threaded sleeve and nuts engage, they are moving in opposite directions, so that the action is exceedingly rapid when releasing the driving clutch. The driven shaft then slows down and stops, and from this point on to the time it starts in the opposite direction, the action is not so rapid and the reversed motion is obtained without shock. Thus the construction of the device makes it possible to get rapid action when this is most desired, and a slower action at the time when it is most advantageous.

It has been suggested that the throwing in of the threaded saddles or nuts would soon wear out the threads on the bronze sleeves. To overcome this objection the sleeves are attached to the wedge-actuating mechanism with a spring connection, allowing them a movement in either direction one-half the pitch of the threads, so that in case the nuts do not engage the threads when first brought in contact, the slight movement allowed enables them to make the necessary adjustment automatically. Some of these sleeves which have been in constant use for two years, have shown no appreciable wear.

If it is desired to have the driver and driven shaft in parallel, the beveled gears may be dispensed with and the intermediate shaft run direct. In this case the reversal is obtained by one extra spur gear between the intermediate shaft and the driven, on one side of the device. If desired, different speeds may be had on the reverse side by changing gears, or the speed may be the same in either direction. With these modifications the device may be adapted for launch or automobile service, and in fact can be applied

to any service requiring the connection of a prime mover to machinery where it is not convenient to reverse the prime mover itself.

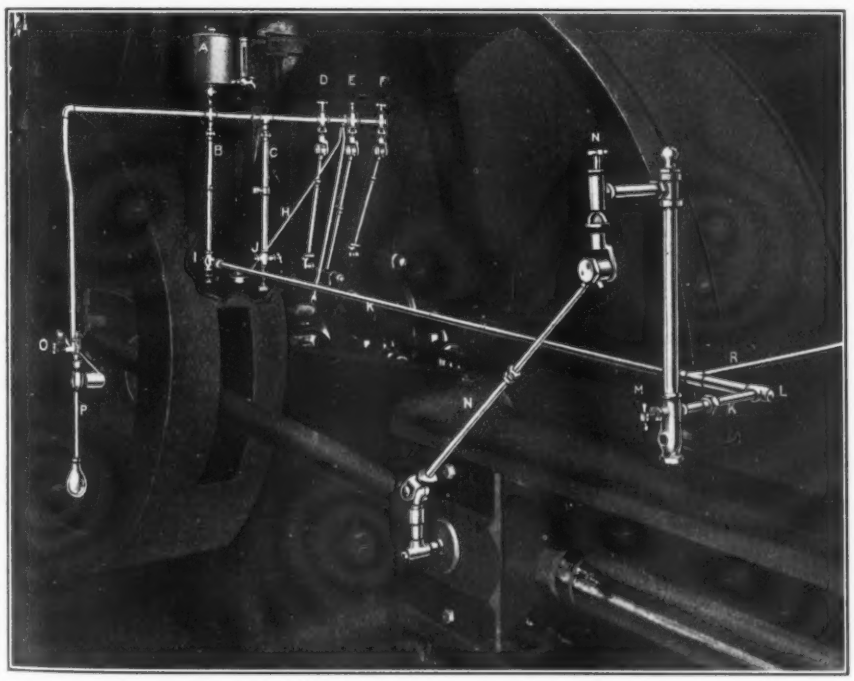
Nugent Gravity Oiling System

The accompanying illustration shows a Nugent oiling system applied to a Corliss engine. The oil is fed to the system from the tank *A*, mounted upon one of the standards, and feed pipes *B*. This tank is provided with a gage glass and valve. The tank may be placed on the wall near the throttle valve, or any convenient place, so that the engineer when he starts his engine, may reach over and turn on the oil.

All important bearings about the engine are supplied with oil from the one reservoir. There are sight-feed-regulating valves at each bearing, and all the reciprocating bearings, such as the crank pin, crosshead pin and eccentrics, which are supplied with telescopic oiling devices, are in constant communication with the oil supply, which insures positive lubrication.

The standard *C* supports the overhead pipes and tank and conveys the oil through the sight-feed valves *I* and *J* to the main bearing, when three feeds are necessary for the main bearing; *D E F* are sight valves which regulate the flow of oil to the three eccentrics; *H* is one leg of the supports, which is fastened to the pillow-block cap; *K* is the oil-pipe line that conveys the oil to the back bearing through the pipe *R* and to the top guide and crosshead pin through valve *M*, and the telescopic crosshead-oiling device *N*; *L* is a plugged tee, and the main oil supply may be connected here or connection made to the steam pipe for blowing out the steam; *O* is a drip valve, which regulates the flow of oil to the crank-pin center oiler *P*.

This oiling system is manufactured by William W. Nugent & Co., 18 to 30 West Randolph street, Chicago, Ill.

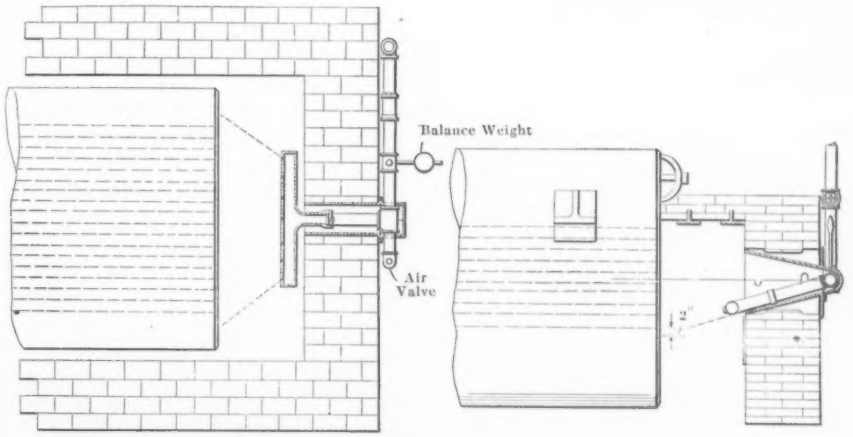


NUGENT GRAVITY OILING SYSTEM APPLIED TO A CORLISS ENGINE

The American Flue Blower

The construction of this flue blower is shown in the accompanying illustration. The blower is placed in the rear wall of the boiler setting, and may be operated from the rear or side walls; it blows with the natural draft of the boiler, and is arranged to blow a solid sheet of steam across the entire width of the boiler and directly into the flues at the least possible angle, driving the soot forward and up the smokestack. Only a few minutes each day is required to thoroughly cleanse the tubes.

This device is manufactured by Eugene J. Feiner, 816 South Broadway, St. Louis, Missouri.



SIDE AND END VIEWS OF TUBE CLEANER ARRANGED IN THE BOILER SETTING

Smooth-On Asbestos Sheet Packing

A type of asbestos sheet packing which should find favor with engineers is known by the above title. It consists of asbestos woven metallic cloth with Smooth-On elastic-iron cement permeating its fibers. In appearance the sheet packing represents the ordinary weaving of coarse duck canvas, the weaving feature insuring against its pulling apart as in the case of ordinary sheet asbestos. The packing is strong and pliable and is said to withstand very high temperatures and is adaptable for gasolene engines, superheated steam, hot gas and water joints. It is made in two thicknesses, the 1/32-inch weighing 4 pounds per square yard and the 1/16-inch weighing 5 pounds per square yard. It is claimed that it can be kept in stock and will not deteriorate.

The idea of utilizing Smooth-On in the packing is because it has the same action as when in the powdered cement form, i.e., it expands slightly when coming in contact with water or steam, thus having a tendency to fill any uneven place in the flange face and make a more perfect joint than if the Smooth-On were eliminated. It is said that this packing does not have to be followed up.

Another point claimed for this packing is that the Smooth-On metallizes when it comes in contact with steam or water, which action strengthens and protects the asbestos fiber, making it practically waterproof. As Smooth-On is said to have the same expansion and contraction properties as iron, this action makes a tight joint at different temperatures.

Smooth-On asbestos sheet packing is manufactured by the Smooth-On Manufacturing Company, 572 and 574 Communipaw avenue, Jersey City, N. J.

A New Revolution Counter

The Veeder Manufacturing Company, of Hartford, Conn., has put on the market a revolution counter which obviates the necessity of having a stop-watch in taking the speed of an engine or other shaft; the new instrument is illustrated by the accompanying engravings. It is so compact that it can be readily carried in a vest pocket; it operates in either direction with no change and has a direct-reading register, which is thrown into or out of engagement with the pointed shaft by means of a clutch and spring. Fig. 1 shows the general appearance of the instrument and Fig. 2 a longitudinal section through the center of it. The spindle of the register carries a lug *A* and the main spindle carries a corresponding lug *B*. When not in use, these two lugs are separated by the spring *C*, which forces the main spindle outward to the position shown. To use the instrument, the point is inserted in the "center" recess in the end of the engine or other shaft, holding an ordinary watch having a second hand in the other hand. When the second hand is at the beginning of a minute, a slight pressure on the end of the instrument throws the clutch into engagement, and it remains engaged as long as pressure is maintained; as soon as pressure is released, which is done at the end of a minute, the spring *C* throws the clutch out of engagement and stops the register, which then shows the number of revolutions that the shaft has made. The register is not made to be reset at zero after use; hence the reading of the register must be taken before starting to count the revolutions of a shaft. This should be jotted down on a piece of paper, and at the end of the count the second reading written above the first; the difference of the two readings will, of course, be the number of revolutions made by the shaft in one minute. The counter will add if driven in one direction and subtract if driven the opposite way. For use with electrical machinery a sleeve having a rubber tip is provided in order to avoid electrical connection between the machine and the speed indicator. The instrument is not affected by magnetism and can be used at speeds as high as 5000 revolutions per minute.

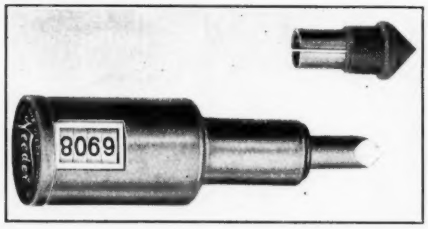


FIG. 1. VEEDER REVOLUTION COUNTER

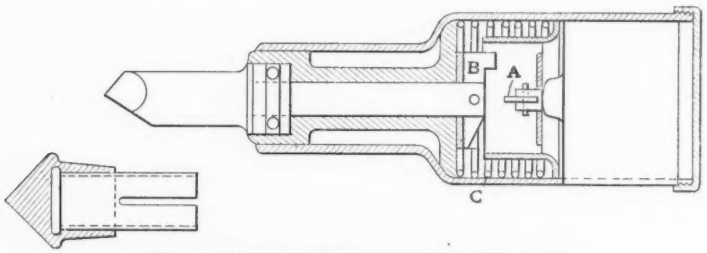


FIG. 2. CONSTRUCTION OF VEEDER INDICATOR

A Centrifugal Lubricating Bearing

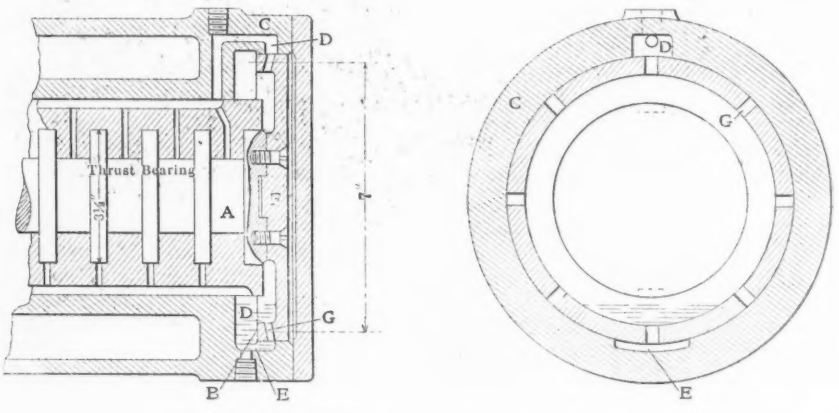
The accompanying illustration shows side and end sectional views of a centrifugal lubricating bearing designed by Oscar K. Holst, 445 West Twenty-first street, New York City.

In the illustration, *A* represents the shaft of a centrifugal pump. Secured to the end of this shaft is a ring *F*, rotating inside another ring *C*. The flange *D* of the ring *C* is provided with a number of canals, shown at *E*. The ring *C* has two openings, one at *D* at the top, and one at *E* at the bottom.

When the lubricator operates, which is only possible when the centrifugal force of the ring *B* is greater than the gravity, the canal *G* will be filled with oil from the oil chamber *D* in the bottom of the bearing.

The oil is carried to the top of the ring and when the canal *E* passes the opening *D* the oil, due to centrifugal force, is forced into this canal, which, becoming filled with oil, is forced to the shaft and, after lubricating it, returns to the oil chamber.

This device has been designed for lubricating high-speed shafts, such as steam turbines, thrust bearings of centrifugal pumps, etc.



SIDE AND END VIEWS OF CENTRIFUGAL BEARING OILER

A New Gas Producer

W. Thomas, a gas engineer of Vancouver, B. C., has designed a gas producer particularly for the generation of gas, for power or illuminating purposes, from waste products, such as low-grade coal refuse, sawmill waste or garbage. The producer comprises an inclosed chamber with refractory material and having a feed hopper through which the refuse is delivered. This chamber is subdivided, preferably into three relatively deep furnace chambers, each of which is provided with an independent grate, beneath which air under pressure or steam may be delivered at will. Each is also provided, adjacent to the furnace grate, with a gas-delivery passage, which passages are connected through the necessary scrubbers and cleaners to the gasometer, or to a gas engine or engines, if direct suction is used.

In use, only one of these gas-delivery passages is open at one time and, the furnaces being charged with fuel, it is blown into incandescence by an air blast admitted beneath the grates. When this condition is attained the air blast is cut off and steam is delivered instead through two of them. This steam passing through the incandescent fuel is dissociated and forms what is known as water gas, which, passing upward through the green fuel, is enriched thereby and carries with it the vapors and volatile elements therefrom.

An important feature of the producer lies in its interchangeability in the direction of the flow of gas, in the three generating furnaces, which enables any one of the furnaces to be recharged without interfering with the continuity of the gas production.

Inquiries

Questions are not answered unless they are of general interest and are accompanied by the name and address of the inquirer.

Water a Poor Heat Conductor

Will you please state whether water is a good or poor conductor of heat?

W. R. O.

Water is one of the poorest conductors of heat, and if it were possible to prevent circulation it would make an almost ideal insulation against heat.

Location of Fusible Plugs

Where and how should a fusible plug be placed in an upright boiler?

C. D.

In a vertical boiler the fusible plug should be placed in one of the tubes at the hight of the bottom of the gage glass. A handhole is cut in the side of the boiler at the proper hight, through which the tube is drilled, tapped and the plug screwed into the tube. Sometimes the regular tube is removed and a heavier tube, called a "stay tube," is put in its place, and into it the plug is screwed.

Equivalent Evaporation from and at 212 Degrees

In the reports of boiler tests, what is meant by the expression "equivalent evaporation from and at 212 degrees?"

T. E. C.

It means that the evaporation under actual conditions has been reduced to standard terms. The evaporation is considered to have taken place at atmospheric pressure and from feed water supplied to the boiler at a temperature of 212 degrees. It is as if the water was fed to the boiler at boiling temperature and the steam allowed to escape through an open manhole. In evaporating 1 pound of water from and at 212 degrees, 965.7 B.t.u. are expended on the water.

Compound Condensing Engine Practice

With a compound-condensing engine having cylinders of 16 and 32 inches in diameter and 42 inches stroke, running at 80 revolutions per minute, what horsepower should the engine develop with 125 pounds boiler pressure? How many feet of cooling surface should there be in the condenser and how many pounds of steam should be used per horsepower per hour?

C. B. G.

The horsepower developed will depend on the point of cutoff. At one-fifth cutoff, 300; at one-fourth cutoff, 375, and at one-third cutoff, 450 indicated horsepower should be developed with a 26-inch vacuum.

The amount of cooling surface required per engine horsepower in a condenser depends on several factors, such as terminal pressure, quantity of steam to be condensed, temperature of overflow and circulating water. With a terminal pressure of 6 pounds absolute in the low-pressure cylinder and circulating water temperature at 60 degrees, 1½ square feet of cooling surface per indicated horsepower is sufficient, while with a terminal pressure of 30 pounds absolute 3 square feet would be needed.

A good general rule for ordinary stationary-engine practice is to allow 2 square feet of cooling surface for each indicated horsepower. An old rule made the cooling surface of the condenser equal to one-half the heating surface of the boiler.

A compound-condensing engine in good order, working at its normal rating, should not exceed a steam consumption of 16 pounds of water per indicated horsepower per hour, and in some cases may be reduced to 12½.

Book Reviews

ERECTING WORK. Compiled and written by Hubert E. Collins. Hill Publishing Company, 505 Pearl street, New York. Cloth; 140 pages, 5x7 inches; illustrated. Price, $1.

The publishers of POWER contemplate the issue of a number of monographs upon different phases of the subject. One of the first of these is the book under review, which deals with the handling of large machinery from the cars to the place where it is to be used, and of its erection at that point. It tells how foundations should be put in, describes the different knots and hitches used with ropes, treats upon the handling of heavy machinery through city streets and up inclined runways into the plant, where a gin pole may be used to advantage, explaining how to rig it, building up flywheels, erection of high-speed center-crank engines, etc. It is largely compiled from the pages of POWER and brings together in a convenient form a lot of information which has not been easily accessible heretofore.

PIPES AND PIPING. Compiled and written by Hubert E. Collins. Hill Publishing Company, 505 Pearl street, New York. Cloth; 140 pages, 5x7 inches; illustrated. Price, $1.

Another of the POWER handbooks is devoted to pipes and piping. It gives general rules for the design of high- and low-pressure steam piping in power plants, considers the forces involved and how they can best be met, describes high-pressure steam-pipe flanges, how to deal with vibration, directions for connecting boilers to steam mains, accidents due to faulty piping, effect of superheated steam on cast-iron valves and fittings, and a lot of other information which the engineer who has, or expects to have, anything to say about the putting in of piping systems should have in a convenient form for reference. It is compiled largely from the pages of POWER and the material has had the benefit of critical consideration by the practical clientele of that paper.

KNOCKS AND KINKS: Causes, Detection and Cure for many of the Commonest of these Troubles of the Engine Man. Plain Directions for the Prevention and Remedy. Compiled and written by Hubert E. Collins. Hill Publishing Company, 505 Pearl street, New York. Cloth; 137 pages, 5x7 inches. Price, $1.

In a running engine a knock is the first indication that something is wrong. It may or may not be serious, but is always annoying, and every operating engineer of any experience has had his share of trouble in running down such a knock and removing its cause. One of the POWER handbooks is devoted to this subject. It begins with a consideration of the causes of knocks, contributed to the columns of POWER by C. J. Larson, until recently the head erecting engineer for the Allis-Chalmers Company. The effect of the inertia of the moving parts is explained and a long chapter devoted to the ready detection and remedy of knocks, taking the subject up analytically and considering the effects of lack of alinement in the rods, of parallelism in boxes, etc., so that one can intelligently diagnose a case. Many instances of troublesome knocks which have been detected and remedied are recounted and will furnish clues to the detection of those which are troubling users of the book.

Books Received

"The Proper Distribution of Expense Burden." By A. Hamilton Church. The Engineering Magazine, New York. Cloth; 116 pages, 5x7½ inches.

"Patents as a Factor in Manufacturing." By Edwin J. Prindle. The Engineering Magazine, New York. Cloth; 134 pages, 4¾x7½ inches; indexed. Price, $2.

"Logarithms for Beginners." Revised. By Charles N. Pickworth. D. Van Nostrand Company, New York. Paper; 47 pages, 4½x7 inches; indexed; tables. Price, $1.

"Water Power Engineering." By Daniel W. Meade. McGraw Publishing Company, New York. Cloth; 787 pages, 5¾x9 inches; 413 illustrations; tables; indexed. Price, $6.

"Notes on Practical Mechanical Drawing." By Victor T. Wilson and Carlos L. McMaster. Wilson & McMaster, East Lansing, Mich. Cloth; 160 pages, 6x9 inches; 66 illustrations.

"Tin Plate Working." By R. H. Clarke. The Technical Publishing Company, Ltd., London, W. C. Cloth; 44 pages, 5x7½ inches; plates; illustrations; tables; indexed. Price, one shilling sixpence.

The "Mechanical World Electrical Pocket Book." Emmott & Co., Ltd., Manchester, England. Cloth; 264 pages, including diary for memoranda for 1909, 3¾x6 inches; illustrated; tables. Price, sixpence.

Toronto No. 1, C. A. S. E. Banquet

The twenty-first annual banquet of Toronto Association No. 1, Canadian Association of Stationary Engineers, was held at the Walker Hotel, Toronto, on Friday evening, November 6. About two hundred members and guests were seated at the tables, and an appetizing dinner was served. Among the guests were many prominent manufacturers of Toronto, and also several of the city officials, besides a number of delegates from nearby cities. The speeches were all bright, earnest and interesting and were delivered by Alderman McGhie, Dr. Harper, Controller Harrison, Alderman Sanderson, Principal Eldon and Assistant Principal Kirkland, of the technical school, J. J. Main, Charles Kelly and W. A. Crockett. The occasion was enlivened with songs, interspersed between the addresses, rendered by Robert Wilson, James Hanna, Edward Buckley, E. B. Curzon, W. Morris and E. Kirkland. During the evening Jack Armour entertained with songs, stories and recitals.

The banquet was a grand social success, and great credit is due the following committee: F. Stubbs, president; W. C. Tait, chairman; M. Kerr, secretary-treasurer; Charles Moseley, John G. Bain, J. W. Marr, W. C. McGhie, Joseph Hughes, W. E. Archer and H. E. Terry.

The Canadian Association of Stationary Engineers is justly proud of the prosperous condition of its organization. Four new associations have been installed recently, with others knocking at the door for admittance. The educational committee is endeavoring to obtain models with which to show practical demonstrations in connection with its lectures. The efforts of the association to get into closer touch with the manufacturers are beginning to show results, and it is expected that the next annual convention, at London, Ont., will be the largest and best in the history of the organization.

Trials of Scout Cruiser "Chester"

In preparation for the 2000-mile race of three scout cruisers, the "Chester," "Salem" and "Birmingham," to be held either in December or January, the "Chester" had the first of her standardization trials on the Rockland (Me.) course November 5. The cruiser made twelve runs at varying speeds, using all six of her turbine engines. She was sent three times over the course at a 10-knot speed, three times at 13 knots, and again at 16 and 19 knots, three times at each speed. The test was for the purpose of determining at what particular speed her six turbines can be used together most economically.

The displacement of the "Chester" during this trial was about 4000 tons, which is about 300 tons more than her displacement during her builders' trials, held on the Rockland course some months ago.

The second trial was scheduled for November 6, but before it was completed a slight accident occurred which caused the abandonment of the trial. The third trial was set for November 7

The "Chester" is the Bath cruiser equipped with Parsons turbines, the "Birmingham' the Fore River cruiser equipped with triple-expansion engines, and the "Salem" the Fore River cruiser equipped with Curtis turbines.

A Large Contract

The Pennsylvania Railroad Company on November 2 awarded a contract to the Westinghouse Electrical and Manufacturing Company for the complete electrical equipment of all the Pennsylvania lines between Harrison, N. J., and Jamaica, L. I., including the tunnel system being constructed across Manhattan. The initial expenditure will aggregate $5,000,000.

A Correction

In the article on "Flow of Water in Pipes and Flumes," by Franklin Van Winkle, November 10, 1908, number, an error occurred in Plate III, page 779. The bottom line giving the gross horsepower per foot fall was inadventently laid off in values which are 7½ times too large, an error which resulted from employment of the diagram values of the discharges as cubic feet in place of gallons. Dividing the values given by 7½ will give the correct horsepower.

Personal

Hugh A. Brown has resigned from the Crocker-Wheeler Company, to whose Chicago office he has been attached for several years, to take up the work of sales manager for the Rockaway Coaster Company, of Cincinnati, in which he has an interest.

Business Items

The Hooven-Owens-Rentschler Company, of Hamilton, Ohio, is building a pair of 28, 50 and 80 by 60 pumps of 23,000,000 gallons capacity for the Ridgewood (Brooklyn) pumping station.

The Trill "Triumph" steam-engine indicator, built by the Trill Indicator Company, Corry, Penn., has some distinctive features that are described in a booklet which will be sent to any engineer upon request.

The John H MacGowan Company, of Cincinnati, recently shipped two compound-condensing pumping engines of 3,000,000 gallons capacity each, with condensers and air pumps, to the Coronet Phosphate Company, France City, Fla.

Engberg's Electric and Mechanical Works, St. Joseph, Mich., recently completed a contract for the Associated Pipe Line Company, of San Francisco, which includes twenty-three 2½-kilowatt direct-connected generating sets and switchboards for each set.

James McCrea & Company, Chicago, manufacturers of the "Climax" steam joint clamp and other pipe repairs have brought suit for infringement against the Simplex Engineering Company, of Philadelphia, which has recently placed a pipe-joint clamp on the market.

The York Manufacturing Company, York, Penn., manufacturer of ice-making and refrigerating machinery, reports 17 recent orders, aggregating 1161 tons of refrigeration. Included in the order is a 500-ton vertical single-acting machine, with cross-compound condensing engines for Jacob Ruppert brewery, New York, and a 65-ton compression-side for Kodak, Limited, London, England.

Muralt & Company, 114 Liberty street, New York, have been given the contract for the enlargement and improvement of the hydro-electric plant of the Riverhead (L. I.) Electric Company. The old water wheel will be taken out and Trump vertical-shaft turbines substituted. The electric equipment will be of the three-phase alternating-current type, 60 cycles, 1100 volts, and there will be an auxiliary steam plant for emergencies.

On November 2 the Ridgway Dynamo and Engine Company moved its Philadelphia office from the Girard building to 1017 Witherspoon building. They have placed this office under the management of Robert S. Beecher, who is well known in the steam-engine trade. With their additional lines of side-crank engines and the rapidly improving business conditions throughout the country, they say the prospects are very bright for a largely increased volume of orders during the coming season.

During the recent celebration at Philadelphia of "Founders' Week" each day was given up to a parade. One day there was an industrial parade, manufacturers located in Philadelphia furnishing floats descriptive of the products they are interested in. The Quaker City Rubber Company, of Philadelphia, had three floats in the parade, one illustrating the collection of crude rubber from the trees in South America, one showing the process of rubber manufacture and one showing the finished product.

The Buckeye Boiler Skimmer Company, South End, Toledo, is in receipt of a letter from E. H. France, contractor, of Bloomville, Ohio, in which he says: "I am pleased to say that the Buckeye automatic boiler cleaner which you installed for me some time in June has given entire satisfaction. We cleaned the boiler every week before using the skimmer; now, after running 30 days, we find it free of mud and practically free from scale. We expect to let it run six weeks next time. I consider it a great saver of fuel, as boilers were fired very hard last of the week. I can recommend it to any one as a saver of fuel and labor."

The E. Keeler Company, Williamsport, Penn. has just been awarded a large contract, consisting of twelve 410-horsepower Keeler water-tube boilers, by the Isthmian canal commission. These boilers will be used in two plants, one of these being situated at Gatun, and the other at Miraflores, on the line of the Panama canal. They will be used to operate the cableways and other machinery for building the locks and dams. These points are situated about nine miles from either end of the canal, Gatun being on the Atlantic and Miraflores on the Pacific side of the isthmus. This is the largest boiler order placed by the Government for the per-

A SQUARE DEAL

BACKED BY HONEST GOODS, will keep your name on our books, if we once put it there.

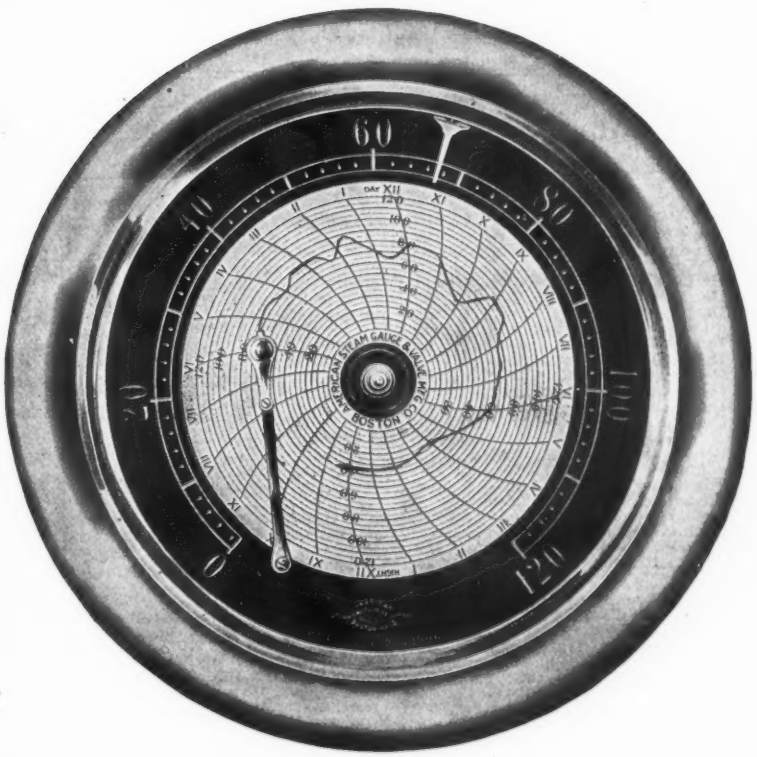
¶ WE MUST HAVE THE FIRST ORDER FROM YOU TO DO THIS.

¶ Send us the order now and we'll show our appreciation by the way we handle your business.

¶ One of the biggest savers among the American Specialties is the AMERICAN COMBINED PRESSURE AND RECORDING GAUGE, shown below.

¶ This Gauge records in legible form the exact pressure carried on your boilers every minute of the day and night and paves the way for many economies.

ASK FOR CIRCULAR 3-B.



ASK FOR CIRCULAR 3-B.

American Steam Gauge & Valve Mfg. Co.

208-220 Camden Street, Boston, Mass.

New York, 26 Cortlandt St. Atlanta, 835 Equitable Bldg. Chicago, 7-9 So. Jefferson St.

Pittsburg, Frick Bldg Annex. San Francisco, 247 Pine Street.
Montreal, 444 St. James Street. Los Angeles, 213 So. Los Angeles Street.

When ordering gauges, valves, indicators and kindred appliances for governing, indicating, measuring, recording and controlling steam, air, gas, oil, ammonia and all other pressures, be sure to specify those manufactured by us. Your interests can be best served by the protection they afford.

manent canal work, and is the first permanent plant to be installed on the isthmus. The boilers will be used in the permanent operation of the canal after the construction is finished. The general contract for this work was taken by the D'Olier Engineering Company, of Philadelphia, and includes the Foster superheaters, made by the Power Specialty Company, and Ajax shaking grates, manufactured by the Valley Iron Works, Williamsport, Penn.

Help Wanted

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

AN ENGINEER in each town to sell the best rocking grate for steam boilers. Write Martin Grate Co., 281 Dearborn St., Chicago.

WANTED—Thoroughly competent steam specialty salesman; one that can sell high-grade goods. Address "M. M. Co.," POWER.

ENGINEERS wanted to sell the Simplex pipe clamp for stopping leaky pipe joints and the Simplex blow-off valve for boilers in evenings among their fellow engineers on a large commission. Write! The Simplex Engineering Co., 326 Preston St., Phila., Pa.

WANTED—A practical mechanical engineer and machinist who thoroughly understands steam and gasolene engines. Must have means to invest in the best thing he ever saw, and make our rotary engine his life work. Parent company organized and three 15 horsepower engines running. Best of references required. Motsinger Rotary Engine Company, Greensburg, Pa.

WANTED—A first class chief electrician to take charge of all electrical equipment at a large mining and furnace plant in the South. Equipment consists of d.c. generators, motors, lights, cranes, locomotives and telephones. Must have a thorough practical knowledge of motor and trolley work, including armature and field winding, and be able to do electrical repair work of any kind. Applicants state age and full qualifications. Box 57, POWER.

Situations Wanted

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

WANTED—Position as advertising manager. Have had years of experience in building catalogs, booklets, folders, etc., also have a practical knowledge of printing values and all details in connection therewith. I hold similar position at the present time, but for good reasons desire a change. Address A. R. M., 1457 Wilson Avenue, Chicago, Ill.

SITUATION WANTED by engineer with 17 years' experience, both locomotive and stationary. Have had machine shop experience, can do boiler work, make engine repairs, handle all kinds of boilers, engines and direct current generators. Last five years have operated electric machinery and ice plants. Do not drink, smoke or chew tobacco; industrious and always work for the good of the plant. Would like a place in the Middle West. Box 38, Chemawa, Oregon.

SITUATION as engineer, have practical and technical education. Experience with dynamos, pumps, Corliss and high speed engines. Correspondence solicited. Box 58, POWER.

MAN, 28 years old, sober, with best of references and technical education, desires position. Holds first class license; will go anywhere. Box 59, POWER.

TECHNICAL GRADUATE, four years' experience in steam and general engineering work, wants position with mining company or young concern with a future. Expert draftsman; will go anywhere. Salary $24.00 a week. Would accept stock as part salary in right company. Box 60, POWER.

Miscellaneous

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

BOILER TUBES CRACKING? Can stop or no pay; any boiler. Wm. Fulton Engineering Co., Office, 28 N. Canal St., Dayton, O.

PATENTS secured promptly in the United States and foreign countries. Pamphlet of instructions sent free upon request. C. L. Parker, Ex-examiner, U. S. Patent Office, McGill Bldg., Washington, D. C.

For Sale

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

FOR SALE—20x48 Wheelock engine and two 72"x18' high pressure tubular boilers in good condition cheap. Address "Engineer," Box 2, Station A, Cincinnati, Ohio.

ONE 23x60 SINGLE-CYLINDER, double-acting Harris Corliss. Pendulum ball governor with sectional cast-iron flywheel, 18 feet by 38 inches; good order, requirements changed, electric power being used. Almond Mfg. Co., Ashburnham, Mass.

FOR SALE—We have for sale one 40-kilowatt, 250-volt direct current Electric Machinery Company belted generator, speed 700 r.p.m. We are installing an a.c. system of the same make and can deliver any time after December 1. The machinery is as good as new. Everett Aughenbaugh & Company, Waseca, Minn.

FOR SALE—One 100-kilowatt alternator, Fort Wayne single phase, 133 cycle, 1100 volts; one 60-kilowatt alternator, Slattery single phase, 133 cycle, 1100-volt. Exciters for same; all in good running condition. Board of Public Affairs, Cuyahoga Falls, Ohio.

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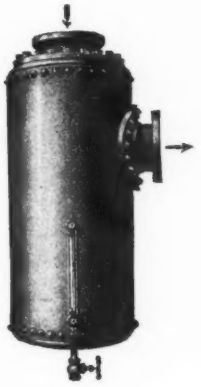
COCHRANE SEPARATORS

WHERE TO USE RECEIVER SEPARATORS



Suppose you have spent $2000 or $5000 for a high-grade steam engine, have it all installed and running nicely, with the whole factory busy, and then, due, perhaps, to the carelessness of a green man, or, perhaps, to a heavy pull for steam that the boilers cannot supply without priming, water from the steam main knocks out a cylinder head? Would not it have been good insurance to have put in a Cochrane Receiver Separator that would have taken care of the water? On most kinds of insurance you have to pay out money continually without any coming back, but a Cochrane Separator more than pays for itself as it goes along, because some moisture, due either to priming or condensation in the steam lines, is always carried over and, if not taken out by a separator, enters the engine cylinder, washes away the lubricant, increases friction and diminishes engine efficiency by robbing the cylinder walls of heat.

A Cochrane Receiver Separator not only stops moisture in the steam, but keeps a good bit of it from ever getting there. The large receiver capacity equalizes the flow of steam and thus diminishes the tendency to priming. Not only this, but the steam mains can be made smaller and still maintain the same initial pressure in the steam chest. Reducing the size of the steam pipes, reduces the losses of heat from them and therefore the condensation. Heat corresponding to from ½ to 4 lbs. of coal per hour is radiated from every square foot in the piping system. The Separator reduces also the first cost, so that the separator not only gives you insurance, pays for itself every day, but makes it possible for you to save its cost in piping, fittings, etc., in the first place.

Then there is another point, the Separator lessens vibration of pipe lines due to pulsations of steam. The receiver of the separator acts as a cushion for the column of steam, and should always be used where there is trouble on this score. While you are getting a separator, get a good one,—one that will not only stop slugs of water, but will also be efficient in taking out the small percentage of suspended moisture; further, get one that has a large enough receiver to hold any flushes of water until the trap can drain them off. Such a separator is the Cochrane.

All we have said above about reciprocating engines, applies with still greater force, except as to oil and vibration, in the case of steam turbines, which are quickly damaged by water in the steam. Write us about your conditions.

HARRISON SAFETY BOILER WORKS,
17TH. & CLEARFIELD STS., PHILADELPHIA, PA.

TALK IO

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Arch, Back Combustion Chamber

McLeod & Henry Co., Troy, N. Y.
Mayville Specialty Mfg. Co, Mayville, Wis.

Arch, Boiler

McLeod & Henry Co., Troy, N. Y.

Arch, Boiler Door

Mayville Specialty Mfg. Co., Mayville, Wis
McLeod & Henry Co., Troy, N. Y.
Presbrey Fire Brick Co., Taunton, Mass.

Asbestos Goods

Carey Co., Philip, Cincinnati, O.
Johns-Manville Co., H. W., New York.
Restein Co., Clement, Philadelphia, Pa.

Bars, Cylinder Boring

Underwood & Co., H. B., Phila., Pa.

Batteries, Storage

Westinghouse Machine Co., Pittsburg, Pa.

Belt Fasteners

Bristol Company, Waterbury, Conn.

Belting

Anchor Packing Co., Philadelphia, Pa.
Bowers Rubber Works, Oakland, Cal.
Diamond Rubber Co., Akron, Ohio.
Garlock Packing Co., Palmyra, N. Y.
N. Y. Belting & Packing Co., New York.
Peerless Rubber Mfg. Co., New York.
Quaker City Rubber Co., Philadelphia, Pa.
Reeves Pulley Co., Columbus, Ind.
Restein Co., Clement, Philadelphia, Pa.
Rhoads & Sons, J. E., Phila., Pa
Robins New Conveyor Co., New York.
Sawyer Belting Co., New York.
Schieren Co., Chas. A., New York.
Shultz Belting Co., St. Louis, Mo.

Benders, Hydraulic

Watson-Stillman Co., New York.

Bending, Pipe

Harrisburg Pipe & Pipe Bending Co., Harrisburg, Pa.
National Pipe Bending Co., New Haven, Conn.
Pittsburgh Gage & Supply Co., Pittsburgh, Pa.
Whitlock Coil Pipe Co., Hartford, Conn.

Bends, Pipe

Harrisburg Pipe and Pipe Bending Co., Harrisburg, Pa.
Pittsburgh Gage and Supply Co., Pittsburgh, Pa.
Whitlock Coil Pipe Co., Hartford, Conn.

Blocks, Chain

Yale & Towne Mfg. Co., New York.

Blowers

Beggs & Co., James, New York
De Laval Steam Turbine Co., Trenton, N. J.
Green Fuel Economizer Co., Matteawan, N. Y.
McClave-Brooks Co., Scranton, Pa.
Ohio Blower Co., Cleveland, O.
Scully Steel & Iron Co., Chicago, Ill.
Sirocco Engineering Co., New York.
Sturtevant Co., B. F., Hyde Park, Mass.
Wing Mfg. Co., L. J., New York.

Blowers, Furnace

McClave-Brooks Co., Scranton, Pa.

Boiler Skimmers

Buckeye Boiler Skimmer Co., Toledo, Ohio.

Boilers, Second Hand

Wickes Boiler Co., Saginaw, Mich.

Boilers, Tubular

Allis-Chalmers Co., Milwaukee, Wis.
Babcock & Wilcox Co., New York.
Beggs & Co., James, New York.
Edge Moor Iron Co., Edge Moor, Del.
Fort Wayne Foundry & Machine Co., Fort Wayne, Ind.
Griffith & Wedge Co., Zanesville, O
Heine Safety Boiler Co., St. Louis, Mo.
Keeler & Co., E., Williamsport, Pa.
Kewanee Boiler Co., Kewanee, Ill.
Oil Well Supply Co., Oswego, N. Y.
Robb-Mumford Boiler Co., South Framingham, Mass.
Struthers-Wells Co., Warren, Pa.
Vilter Mfg. Co., Milwaukee, Wis.
Wetherill & Co., Robert, Chester, Pa.
Wickes Boiler Co., Saginaw, Mich.

Boilers, Water Tube

Allis-Chalmers Co., Milwaukee, Wis.
Babcock & Wilcox Co., New York.
Edge Moor Iron Co., Edge Moor, Del.
Heine Safety Boiler Co., St. Louis, Mo.
Keeler Co., E., Williamsport, Pa.
Kewanee Boiler Co., Kewanee, Ill.
Morrin Climax Boiler Co., Brooklyn, N. Y.
Oil Well Supply Co., Oswego, N. Y.
Parker Boiler Co., Philadelphia, Pa.
Robb-Mumford Boiler Co., South Framingham, Mass.
Rust Boiler Co., Pittsburg, Pa.
Struthers-Wells Co., Warren, Pa.
Vogt Machinery Co., Henry, Louisville, Ky.
Wetherill & Co., Robt., Chester, Pa.
Wickes Boiler Co., Saginaw, Mich.

Books

American School of Correspondence, Chicago, Ill.
Hill Publishing Co., New York.
International Text Book Co., Scranton, Pa.
System Co., Chicago, Ill.

Boosters

Ridgway Dynamo & Engine Co., Ridgway, Pa.

Brick, Fire

C-O-Two Furnace Co., Syracuse, N. Y.
McLeod & Henry Co., Troy, N. Y.
Presbrey Fire Brick Co., Taunton, Mass.

Building Materials, Fireproof

Carey Co., Philip, Cincinnati, O.
Johns-Manville Co., H. W., New York.

Castings, Brass and Iron

Homestead Valve Mfg. Co., Pittsburg, Pa.
McClave-Brooks Co., Scranton, Pa.
Ohio Brass Co., Mansfield, O.
Pittsburgh Gage and Supply Co., Pittsburgh, Pa.

Castings, General

Neemes Bros., Troy, N. Y.

Castings, Malleable

Jeffrey Mfg. Co., Columbus, O.

Cement, Asbestos

Johns-Manville Co., H. W., New York.
N. Y. Belting & Packing Co., New York.

Cement, Boiler

Smooth-On Mfg. Co., Jersey City, N. J.

Chimneys

Weber Co., Chicago, Ill.
Wiederholdt Construction Co., Chicago, Ill.

Chimneys, Reinforced Concrete

Wiederholdt Construction Co., Chicago, Ill.

Chimneys, Steel Concrete

Weber Co., Chicago, Ill.

Clamp, Steam Joint

McCrea & Co., James, Chicago, Ill.

Clamp, Pipe

McCrea & Co., James, Chicago, Ill.
Simplex Engineering Co., Philadelphia, Pa.

Cleaners, Tube

Buckeye Boiler Skimmer Co., Toledo, Ohio.
Chesterton Co., A. W., Boston, Mass.
Garlock Packing Co., Palmyra, N. Y.
General Specialty Co., Buffalo, N. Y.
Lagonda Mfg. Co., Springfield, O.
Liberty Mfg. Co., Pittsburg, Pa.
McCrea & Co., James, Chicago, Ill.
Pierce Co., Wm. B., Buffalo, N. Y.
Robertson & Sons, Jas. L., New York.
Scully Steel & Iron Co., Chicago, Ill.
Stewart Heater Co., Buffalo, N. Y.

Clocks

American Steam Gauge and Valve Mfg. Co., Boston, Mass.

Clutches, Friction

Reeves Pulley Co., Columbus, Ind.
Williams Fdry. & Mach. Co., Akron, Ohio.

Cocks, Blow-Off

Liberty Mfg. Co., Pittsburg, Pa.
Lunkenheimer Co., Cincinnati, O.
Pittsburgh Gage and Supply Co., Pittsburgh, Pa.

Cocks, Gage

American Steam Gauge & Valve Mfg. Co., Boston, Mass.
Huyette Co., P. B., Philadelphia, Pa.
*Ohio Brass Co., Mansfield, Ohio.
Pittsburgh Gage and Supply Co., Pittsburgh, Pa.

Cocks, Gage—*Continued.*

Reliance Gauge Column Co., Cleveland, O.
Williams Valve Co., D. T., Cincinnati, Ohio.

Cocks, Steam

Homestead Valve Mfg. Co., Pittsburg, Pa.
Williams Valve Co., D. T., Cincinnati, O.

Compound, Boiler

Binghamton Boiler Compound Co., Binghamton, N. Y.
Bird-Archer Co., New York.
Buckeye Boiler Skimmer Co., Toledo, Ohio.
Dearborn Drug & Chemical Co., Chicago, Ill.
Hawk-Eye Compound Co., Chicago, Ill.
Johns-Manville Co., H. W., New York.

Compound, Lubricating

Cook's Sons, Adam, New York.
Houghton & Co., E. F., Philadelphia, Pa.

Condensers

Alberger Condenser Co., New York
Allis-Chalmers Co., Milwaukee, Wis.
Baragwanath & Son, Wm., Chicago, Ill.
Deane Steam Pump Co., Holyoke, Mass.
Epping-Carpenter Co., Pittsburg, Pa.
Minneapolis Steel & Mach'y Co., Minneapolis, Minn.
Schutte & Koerting Co., Philadelphia, Pa.
Stewart Heater Co., Buffalo, N. Y.
Southwark Foundry and Machine Co., Philadelphia, Pa.
Wheeler Condenser and Engineering Co., New York.

Consumers, Smoke

Climax Smoke Preventer Co., Boston, Mass.

Controllers, Electric

General Electric Co., Schenectady, N. Y.
Westinghouse Electric and Mfg. Co., Pittsburg, Pa

Controllers, Feed Water

American Boiler Economy Co., Philadelphia, Pa.

Cooling Apparatus, Air

De La Vergne Machine Co., New York.
Triumph Ice Machine Co., Cincinnati, Ohio.

Cooling Towers

Alberger Condenser Co., New York.
Baragwanath & Sons, Wm., Chicago, Ill.
Wheeler Condenser and Engineering Co., New York.

Correspondence Schools

American School of Correspondence, Chicago, Ill.
International Correspondence Schools, Scranton, Pa,

Couplings, Clutch

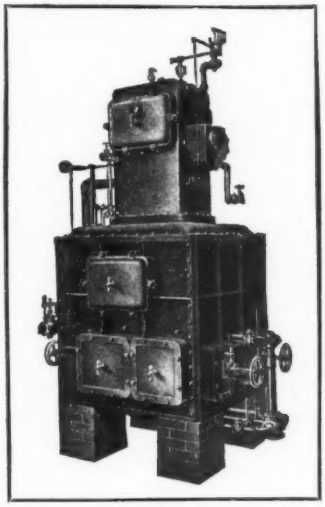
Williams Fdry. & Mach. Co., Akron, Ohio

Covering, Pipe and Boiler

Carey Co., Philip, Cincinnati, O.
Houghton & Co., E. F., Philadelphia, Pa.
Johns-Manville Co., H. W., New York.
U. S. Mineral Wool Co., New York.

Covering, Pulley

Houghton & Co., E. F., Philadelphia, Pa.



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ANY kind of a waste is expensive—if you have a feed water heater, purifier and filter through which all your exhaust steam is passed, when only a part is necessary, then you're wasting money—for exhaust *is* money nowadays. That's one way the "WEBSTER" saves.

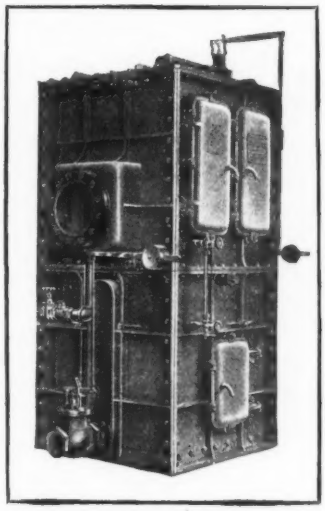
Then again the heater must be perfectly adapted to individual conditions. The "WEBSTER" is. In a word, we will not place one of our heaters until we can *guarantee* finest results.

Booklet 12-F gives details.

Webster Feed Water Heaters

AND

Chemical Purifiers



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IT stands to reason that some feed water is so impure, and so full of scale-forming properties, that the only way to make it economically usable is by chemical treatment. For such cases the Webster Chemical Purifier is invaluable. It treats the water *while it is hot*, supplying the chemicals (determined by expert analysis in each case) necessary to make clean, pure boiler feed. This Purifier makes the locating of a plant entirely independent of the water supply.

Descriptive Booklet 12-C will interest you.

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20

Crabs

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Cranes

Yale & Towne Mfg. Co., New York.

Die Stocks

Bignall & Keeler Mfg. Co., Edwardsville, Ill.
Curtis & Curtis Co., Bridgeport, Conn.
Loew Mfg. Co., Cleveland, O.
Oster Mfg. Co., Cleveland, O.

Draft Apparatus, Mechanical

Green Fuel Economizer Co., Matteawan, N. Y.
Wing Mfg. Co., L. J., New York.

Dressing, Belt

Cling-Surface Co., Buffalo, N. Y.
Dixon Crucible Co., Jos., Jersey City, N. J.
Garlock Packing Co., Palmyra, N. Y.
Houghton & Co., E. F., Philadelphia, Pa.
Johnson Co., Henry, Jersey City, N.J.
Rhoads & Son, J. E., Phila., Pa.
Schieren Co., Chas. A., New York.
Shultz Belting Co., St. Louis, Mo.
Stephenson Mfg. Co., Albany, N. Y.
Walton Co., F. S., Philadelphia, Pa.

Dressing, Rope

Cling-Surface Co., Buffalo, N. Y.

Drills, Upright

Barnes Co., W. F. & John, Rockford, Ill.

Dynamos

Allis-Chalmers Co., Milwaukee, Wis.
Clark Bros. Co., Belmont, N. Y.
Fort Wayne Electric Works, Ft. Wayne, Ind.
General Electric Co., Schenectady, N. Y.
Northern Electrical Mfg. Co., Madison, Wis.
Ridgway Dynamo & Engine Co., Ridgway, Pa.
Triumph Electric Co., Cincinnati, O.
Westinghouse Electric and Mfg. Co., Pittsburg, Pa.

Educational

American School of Correspondence, Chicago, Ill.
International Correspondence Schools, Scranton, Pa.

Ejectors

Beggs & Co., James, New York.
Lunkenheimer Co., Cincinnati, O.
Ohio Injector Co., Wadsworth, O.
Penberthy Injector Co., Detroit, Mich.

Engineers, Electrical

Northern Electrical Mfg. Co., Madison, Wis.

Engines, Corliss

Allis-Chalmers Co., Milwaukee, Wis.
Bates Machine Co., Joliet, Ill.
Beggs & Co., James, New York.
Cooper Co., C. & G., Mt. Vernon, O.
Griffith & Wedge Co., Zanesville, O.
Minneapolis Steel & Mach'y Co., Minneapolis, Minn.
Providence Eng. Works, Providence, R. I.
Southwark Foundry and Machine Co. Philadelphia, Pa.
Vilter Mfg. Co., Milwaukee, Wis.
Watertown Engine Co., Watertown, N. Y.
Wetherill & Co., Robert, Chester, Pa.
Wheeler Condenser & Engineering Co., New York.

Engines, Gas and Gasolene

Alberger Co., A. H., Buffalo, N. Y.
Atlis Chalmers Co., Milwaukee, Wis.
Buckeye Engine Co., Salem, Ohio.
De La Vergne Machine Co., New York.
Du Bois Iron Works, Du Bois, Pa.
Engberg's Electric & Mechanical Works St Joseph, Mich.
Foos Gas Engine Co., Springfield, O.
Fort Wayne Foundry & Machine Co., Fort Wayne Ind.
Minneapolis Steel & Mach'y Co., Minneapolis, Minn.
Riverside Engine Co., Oil City, Pa.
Struthers-Wells Co., Warren, Pa.
Westinghouse Machine Co., Pittsburg, Pa.

Engines, High Speed

Allis-Chalmers Co., Milwaukee, Wis.
American Diesel Engine Co., New York.
American Engine Co., Bound Brook, N. J.
Ball Engine Co., Erie, Pa.
Bates Machine Co., Joliet, Ill.
Buckeye Engine Co., Salem, Ohio.
Clark Bros. Co., Belmont, N. Y.
Engberg's Electric & Mechanical Works, St. Joseph, Mich.
Erie Mfg. & Supply Co., Erie, Pa.
Fitchburg Steam Eng. Co., Fitchburg, Mass.
Minneapolis Steel & Mach'y Co., Minneapolis, Minn.
Shepherd Engineering Co., Williamsport, Pa.
Skinner Engine Co., Erie, Pa.
Southwark Foundry & Machine Co., Philadelphia, Pa.
Watertown Engine Co., Watertown, N. Y
Westinghouse Machine Co., Pittsburg, Pa.

Engines, Medium and Low Speed

Allis-Chalmers Co., Milwaukee, Wis.
American Diesel Engine Co., New York.
Ball Engine Co., Erie, Pa.
Buckeye Engine Co., Salem, Ohio.
Erie Mfg. & Supply Co., Erie, Pa.
Fitchburg Steam Engine Co., Fitchburg, Mass.
Minneapolis Steel & Mach'y Co., Minneapolis, Minn.
Shepherd Engineering Co., Williamsport, Pa.
Skinner Engine Co., Erie, Pa.
Southwark Foundry & Mach. Co., Philadelphia, Pa.
Westinghouse Machine Co., Pittsburg, Pa.

Engines, Oil

American Diesel Engine Co., New York.
De La Vergne Machine Co., New York.

Engines, Rotary

Allis-Chalmers Co., Milwaukee, Wis.
Ball-Cooley Engineering Co., New York.

Engines, Steam

Allis-Chalmers Co., Milwaukee, Wis.
Ball & Wood Co., Elizabethport, N. J.
Ridgway Dynamo & Engine Co., Ridgway, Pa.

Exhaust Heads

Burt Mfg. Co., Akron, O.
Gardner Gov. & Separator Co., Quincy, Ill.
Hoppes Mfg. Co., Springfield, O.
Ohio Blower Co., Cleveland, O.
Pittsburgh Gage and Supply Co., Pittsburgh, Pa.
Whitlock Coil Pipe Co., Hartford, Conn.

Fans, Electric

Crocker-Wheeler Co., Ampere, N. J.
Fort Wayne Electric Works, Ft. Wayne, Ind.
General Electric Co., Schenectady, N. Y.
Triumph Electric Co., Cincinnati, O.
Westinghouse Elec. and Mfg. Co., Pittsburg, Pa.

Fans, Exhaust and Ventilating

Ohio Blower Co., Cleveland, O.
Sirocco Engineering Co., New York.

Fans, Mine Ventilating

Jeffrey Mfg. Co., Columbus, O.

Feeders, Boiler

American Boiler Economy Co., Philadelphia, Pa.
Davis Regulator Co., G. M., Chicago, Ill.
Dean Bros. Steam Pump Works, Indianapolis, Ind.
Lunkenheimer Co., Cincinnati, O
Myers & Bro., F. E., Ashland, O.
Pittsburgh Gage & Supply Co., Pittsburg, Pa.

Filters, Feed Water

Beggs & Co., James, New York.
Eclipse Feed Water Heater and Purifier Co., Appleton, Wis.
Keystone Chemical Co. Philadelphia, Pa.

Filters, Oil

Burt Mfg. Co., Akron, O.
Houghton & Co., E. F., Philadelphia, Pa.
Liberty Mfg. Co., Pittsburg, Pa.
Pittsburgh Gage & Supply Co., Pittsburg, Pa.

Filtration and Softening Plants

Eclipse Feed Water Heater and Purifier Co., Appleton, Wis.
Harrison Safety Boiler Wks., Philadelphia, Pa.

Fittings, Ammonia

American Steam Gauge and Valve Mfg. Co., Boston, Mass.
De La Vergne Machine Co., New York.
Triumph Ice Machine Co., Cincinnati, O.
York Mfg. Co., York, Pa.

Fittings, Boiler

American Steam Gauge and Valve Mfg. Co., Boston, Mass.
Lunkenheimer Co., Cincinnati, O.
Pittsburgh Gage and Supply Co., Pittsburgh, Pa.
Schaeffer & Budenberg Mfg. Co., Brooklyn, N. Y.

Fittings, Flange

Lunkenheimer Co., Cincinnati, O.
Pittsburgh Gage & Supply Co., Pittsburg, Pa.
Pittsburgh Valve & Fittings Co., Barberton, O.
Pittsburgh Valve, Foundry & Construction Co., Pittsburg, Pa.
Williams Valve Co., D. T., Cincinnati, Ohio.

Fittings, Hydraulic

Watson-Stillman Co., New York.

Fittings, Pipe

Triumph Ice Machine Co., Cincinnati, Ohio.
Ohio Brass Co., Mansfield, O.

Fittings, Steel

Nelson Valve Co., Philadelphia, Pa.

Fittings, Steel Pipe

Nelson Valve Co., Philadelphia, Pa.

Flanges

Scully Steel & Iron Co., Chicago, Ill.

Flanges, Welded

Ball & Wood Co., Elizabethport, N. J.

Floats

Anderson Co., V. D., Cleveland, O.
Reliance Gauge Column Co., Cleveland, O.

Flue Gas Analysis Instruments

Pierce Co., Wm. B., Buffalo, N. Y.

Forges

Scully Steel & Iron Co., Chicago, Ill.

Fuel Economizers

Green Fuel Economizer Co., Matteawan, N. Y.

Furnace Tile

C-O-Two Furnace Co., Syracuse, N. Y.

Furnaces

Murphy Iron Works, Detroit, Mich.

Furnaces, Smokeless

McClave-Brooks Co., Scranton, Pa.
Murphy Iron Works, Detroit, Mich.
Wilkinson Mfg. Co., Bridgeport, Penn.

Gage Glasses

American Steam Gauge and Valve Mfg. Co., Boston, Mass.
Chesterton Co., A. W., Boston, Mass.
Garlock Packing Co., Palmyra, N. Y.
Sterling Lubricator Co., Rochester, N. Y.

Gage Testing Outfit

American Steam Gauge and Valve Mfg. Co., Boston, Mass.

Gages

American Steam Gauge and Valve Mfg. Co., Boston, Mass.
Bristol Co., Waterbury, Conn.
Crosby Steam Gage & Valve Co., Boston, Mass.
Huyette Co., Paul B., Philadelphia, Pa.
Lunkenheimer Co., Cincinnati, O.
Pittsburgh Gage & Supply Co., Pittsburg, Pa.
Schaeffer & Budenberg Mfg. Co., Brooklyn, N. Y.

Gages, Ammonia

American Steam Gauge and Valve Mfg. Co., Boston, Mass.
Schaeffer & Budenberg Mfg. Co., Brooklyn, N. Y.

Gages, Pressure

American Steam Gauge and Valve Mfg. Co., Boston, Mass.
Pittsburgh Gage and Supply Co., Pittsburgh, Pa.
Williams Valve Co., D. T., Cincinnati, O.

Gages, Recording

American Steam Gauge and Valve Mfg. Co., Boston, Mass.
Pittsburgh Gage and Supply Co., Pittsburgh, Pa.

Gages, Vacuum

American Steam Gauge and Valve Mfg. Co., Boston, Mass.
Pittsburgh Gage and Supply Co. Pittsburgh, Pa.

Gages, Water

Ohio Brass Co., Mansfield, O.

Gas, Producer

Fort Wayne Foundry & Machine Co., Fort Wayne, Ind.

Gas Producers

Broomell, Schmidt & Steacey Co., York, Pa.
De La Vergne Machine Co., New York.
Fort Wayne Foundry & Machine Co., Fort Wayne, Ind.
Minneapolis Steel & Mach'y Co., Minneapolis, Minn.
Westinghouse Mach. Co., Pittsburg, Pa.

Gaskets

American Goetze-Gasket & Packing Co., New York.
Anchor Packing Co., Philadelphia, Pa.
Brandt, Randolph, New York.
Diamond Rubber Co., Akron, Ohio.
Garlock Packing Co., Palmyra, N. Y.
Houghton & Co., E. F., Philadelphia, Pa.
Jenkins Bros., New York.
Johns-Manville Co., H. W., New York.
Johnson Co., Henry, Jersey City, N. J.
National India Rubber Co., Bristol, R. I.
N. Y. Belting & Packing Co., New York.
Quaker City Rubber Co., Philadelphia, Pa.
Smooth-On Mfg. Co., Jersey City, N. J.
U. S. Mineral Wool Co., New York.

Gaskets, Copper

Restein Co., Clement, Philadelphia, Pa.
U. S. Mineral Wool Co., New York.

Generating Sets

Allis-Chalmers Co., Milwaukee, Wis.
American Engine Co., Bound Brook, N. J.
Crocker-Wheeler Co., Ampere, N. J.
Engberg's Electric & Mechanical Works, St. Joseph, Mich.
Foos Gas Engine Co., Springfield, Ohio.
Fort Wayne Electric Works, Ft Wayne, Ind.
General Electric Co., Schenectady, N. Y.
Northern Electrical Mfg. Co., Madison, Wis.
Ridgway Dynamo & Engine Co., Ridgway, Pa.
Skinner Engine Co., Erie, Pa.
Sturtevant Co., B. F., Hyde Park, Mass.
Watertown Engine Co., Watertown, N. Y.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

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When ordinary oil has leaked out of a bearing, mussed up machines and the floor and perhaps ruined several belts, don't deluge the "hot box" with the same old stuff. Oil will do if you don't mind letting 85% go to waste, and don't mind humoring the bearings.

Greases are not much better. They change from solid to liquid and run OUT as quick as IN the bearings.

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provide against back pressure and provide for extracting every bit of oil and condensation by force of gravity. Write.

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For Steam, Water, Air, Gas, Hydraulic Machines, Valves, Etc

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We guarantee it to make and keep your belts and ropes pliable, preserved and waterproof. To prevent all drying out or cracking and prolong their lives.

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Governors, Pump

American Boiler Economy Co., Philadelphia, Pa.
Berry Engineering Co., Chester, Pa.
Chaplin-Fulton Mfg. Co., Indianapolis, Ind.
Dean Bros. Steam Pump Works, Indianapolis, Ind.
d'Este Co., Julian, Boston, Mass.
Fisher Governor Co., Marshalltown, Iowa.
Gardner, Governor & Separator Co., Quincy, Ill.
Strong, Carlisle & Hammond Co., Cleveland, O.

Graphite

Carpenter Co., W. D., New York.
Dixon Crucible Co., Jos., Jersey City, N. J.
Garlock Packing Co., Palmyra, N. Y.

Grate Bars

Gibson Iron Works Co., Jersey City, N. J.
Salamander Grate Bar Co., New York.

Grates

Green Engineering Co., Chicago, Ill.
McClave-Brooks Co., Scranton, Pa.
Martin Grate Co., Chicago, Ill.
Salamander Grate Bar Co., New York.

Grates, Clinker Cutting

Neemes Bros., Troy, N. Y.

Grates, Shaking and Dumping

Gibson Iron Works Co., Jersey City, N. J.
McClave-Brooks Co., Scranton, Pa.
Martin Grate Co., Chicago, Ill.
Neemes Bros., Troy, N. Y.
Salamander Grate Bar Co., New York.

Grates, Stationary

Gibson Iron Works Co., Jersey City, N. J.
Neemes Bros., Troy, N. Y.
Salamander Grate Bar Co., New York.

Grease

Carpenter & Co., W. D., New York
Cook's Sons, Adam, New York.
Houghton & Co., E. F., Philadelphia, Pa.
Keystone Lubricating Co., Philadelphia, Pa.
New York & New Jersey Lubricant Co., New York

Heaters, Feed Water

Alberger Condenser Co., New York.
Baragwanath & Son, Wm., Chicago, Ill.
Bates Machine Co., Joliet, Ill.
Eclipse Feed Water Heater and Purifier Co., Appleton, Wis.
Erie Mfg. & Supply Co., Erie, Pa.
Griscom-Spencer Co., New York.
Harrison Safety Boiler Wks., Philadelphia, Pa.
Harrisburg Pipe and Pipe Bending Co., Harrisburg, Pa.
Hoppes Mfg. Co., Springfield, O.
Kewanee Boiler Co., Kewanee, Ill
Loew Mfg. Co., Cleveland, O.
National Pipe Bending Co., New Haven, Conn.
Patterson & Co., F. L., New York.
Stewart Heater Co., Buffalo, N. Y.
Webster & Co., Warren, Camden, N. J.
Wheeler Condenser and Engineering Co., New York.
Whiflock Coil Pipe Co., Hartford, Conn.
Wickes Boiler Co., Saginaw, Mich

Heating, District Steam

American District Steam Co., Lockport, N. Y.

Heating and Ventilating Apparatus

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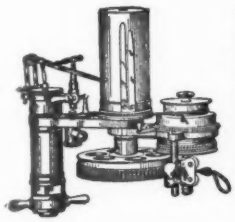

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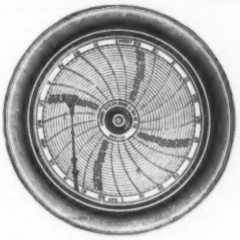

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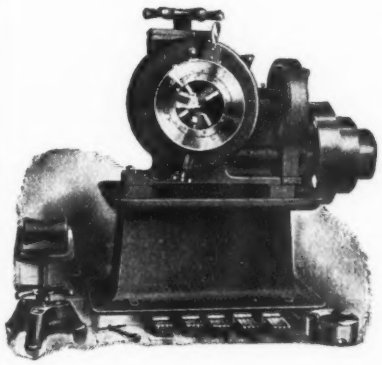

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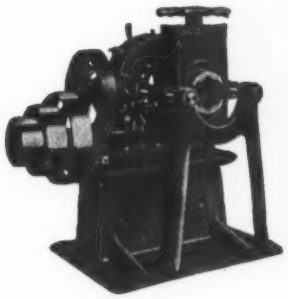

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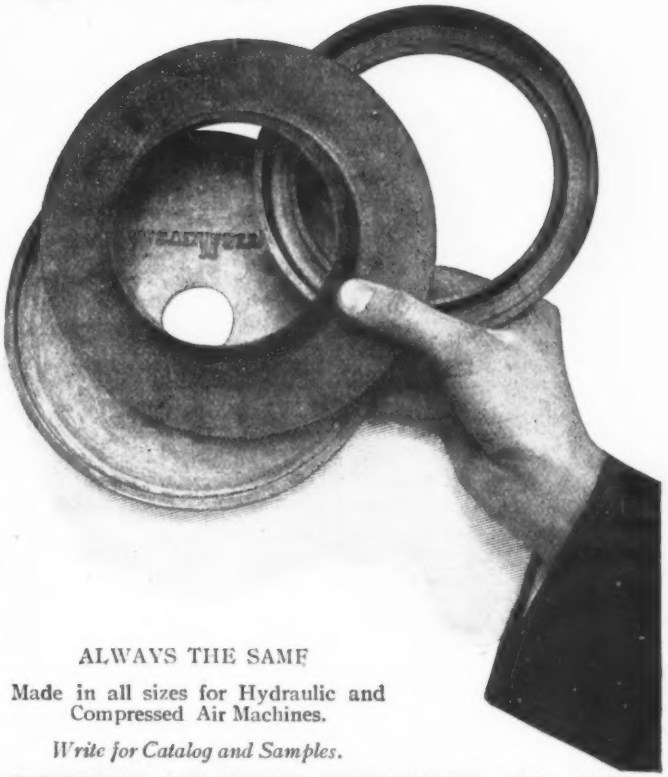

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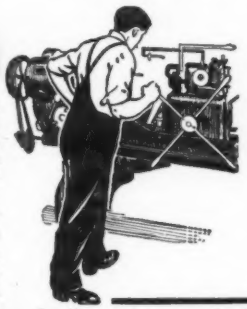

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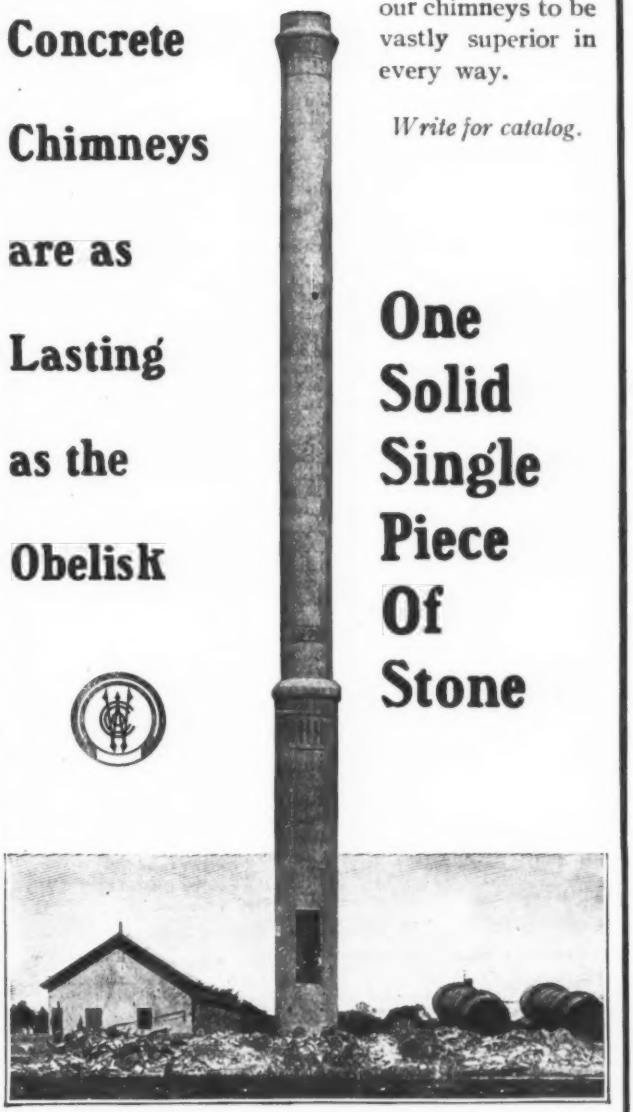

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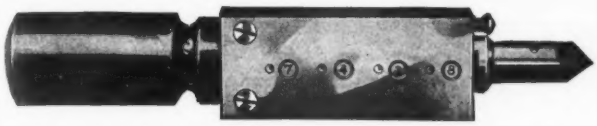

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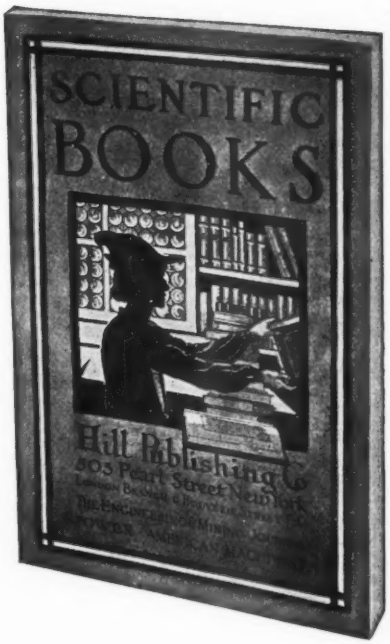

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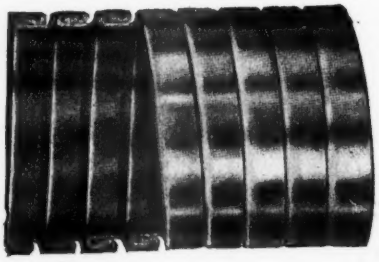

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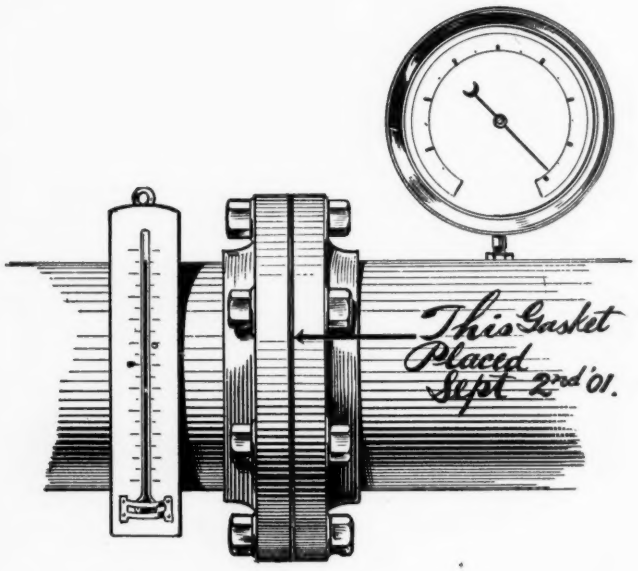

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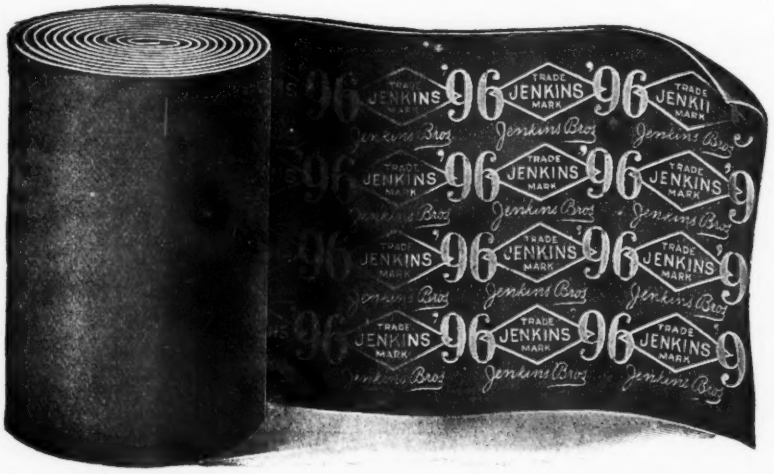

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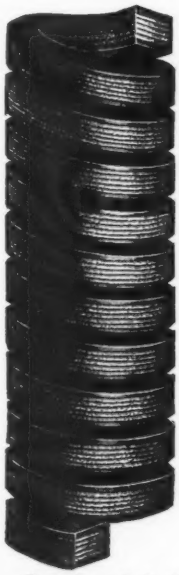

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free to any engineer upon request.

The DIAMOND RUBBER CO., AKRON, OHIO.

Complete Diamond Stocks Carried By

The Diamond Rubber Co. of N. Y.,
1876 Broadway, N. Y.
The Diamond Rubber Co.,
1523 Michigan Ave., Chicago, Ill.
The Diamond Rubber Co.,
Mission and 2nd Sts., San Francisco, Cal.
Buffalo Mill Supply Co.,
Buffalo, N. Y.
Southern Hardware & Supply Co.,
Mobile, Ala.
Consumers Rubber Co.,
Cleveland, Ohio.
The Diamond Rubber Co. of N. Y.,
304 N. Broad St., Philadelphia, Pa.
The Diamond Rubber Co.,
3963 Olive St., St. Louis, Mo.
The Gustin-Bacon Manufacturing Co.,
Kansas City, Mo.
Pittsburgh Rubber & Leather Co.,
Pittsburgh, Pa.
Alabama Machinery & Supply Co.,
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M. I. Wilcox Co.,
Toledo, Ohio.

VANDA

A STEAM PACKING THAT IS A STEAM PACKING

TRADE MARK. REG. IN U. S. PAT. OFF.

All Goods Stamped with the VANDA TRADE-MARK will fulfill the claims we make for them.

VANDA SHEET PACKING

THIS PACKING IS THE PIONEER OF ALL COMPOSITION PACKINGS. AND IMITATORS ARE APPEARING IN GREAT NUMBERS. WE THEREFORE, WOULD ESPECIALLY CALL YOUR ATTENTION TO OUR

TRADE-MARK DEVICE STAMPED ON EVERY SHEET

GOODS MADE IN SHEETS ONLY OF 4½' x 4½' AND 4½' x 9', IN ALL THICKNESSES

THE VANDA COMPANY, 96 SPRING STREET, N. Y.

H. W. JOHNS-MANVILLE CO., CO-DISTRIBUTORS

OLD friends are best friends. The test of time is always a severe one and anyone or anything that survives it, is entitled to, and receives a higher place in your estimation than any others.

For 30 years Engineers have known Genuine Eureka Packing as one of their best friends. It has stood the test of time and the test of severe service in countless plants, because it is made of the finest materials, on scientific principles.

Where the rods are fluted or scored Eureka gives perfect satisfaction for the longest time and reduces friction to an economical minimum. It requires less repacking than others—and its cost is one-third less.

We also make large quantities of Cut Ring, High Pressure, Water Proof Hydraulic in coils and rings, Spiral and Red Sheet Packings.

Ask us for Samples and Prices.

Eureka Packing Co.

Jas. L. Robertson, Pres't
Sales Dept.

46 Warren St., New York.

If your engine isn't running just right you want to know why, when and where, don't you? Then you'll have a knowledge on which to base your hopes for more salary. The sure way to know all about it is to use a Robertson-Thompson Indicator and Victor Reducing Wheel—then you'll have a record that shows clearly just how things stand. You can buy them at a moderate price, on easy terms. Shall we tell you the particulars?

Jas. L. Robertson & Sons,

46 Warren St., New York.

THE PACKING WITH REAL HOLDING QUALITY

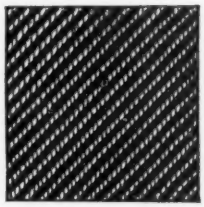
Pat. March 15 1898

DODS Diagonal Piston Rod Packing

is all one piece, made from high-grade Rubber and Duck in layers placed at a diagonal from every side. This construction gives "Dods" a cross expansion of 100%. It will hold steam, air or liquids when all other packings fail.

Send for test samples and description. Address Dept. P.

CROSS-SECTIONS OF "DODS" PACKING. ORDINARY PACKING.



☞ These Cross-Section Views Show Why!

CHICAGO **BOWERS RUBBER WORKS** SAN FRANCISCO

BLACK SQUADRON

(The 4 Wedge Packing)

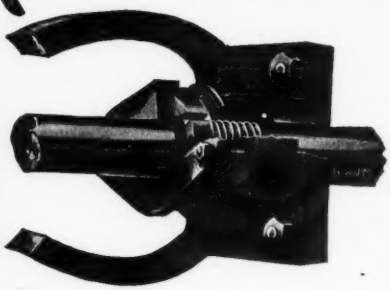
Can be used on rods, where no other packing will give satisfactory results. That's because the 4 wedge design enables it to respond perfectly to every irregularity of the rod or stem. Materials of highest quality throughout; every particle lubricated, keeps rods in perfect condition. *Illustrated catalog on request.*

CANCOS MFG. CO.

Philadelphia, Pa.

10 Oliver St., Boston, Mass. 525 Third Ave., Pittsburg, Pa.
305 Plowman St., Baltimore, Md.

How could Morris Metallic Packing Cut a Valve Stem?



In order to wear there must be friction. As this packing *revolves with the stem*, there is *absolutely no friction*—consequently it cannot score the stem.

MORRIS METALLIC PACKING is made of specially treated, soft, gray cast iron and will last as long as any other wearing part of an engine, if properly cared for.

Can be applied to stem even when already scored, as it is applied on the part usually covered by the old gland.

Write nearest Branch for Catalog 110.

H. W. JOHNS-MANVILLE CO.

New York	St. Louis	Baltimore	Los Angeles
Milwaukee	Pittsburg	New Orleans	Seattle
Chicago	Cleveland	Kansas City	Dallas
Boston	Buffalo	Minneapolis	London
Philadelphia	Detroit	San Francisco	

784

CHESTERTON'S
7 lbs. METALBESTOS ¼ sq. in.
A Packing especially for High Pressures
Economical Durable Cannot Burn or Blow Out

"Metalbestos"

(Trade Mark Registered)

For all High Pressures

The *ideal* packing to use on *Marine or Power Station Work*. The "Rubberbestos" core is covered with *Asbestos*. The outside covering of *Soft Metallic Wire* reduces friction and makes this packing the most durable on the market. It won't *char, burn* or *blow out*.

A. W. CHESTERTON CO.

64 INDIA ST., - - BOSTON, MASS.

Or Advance Packing & Supply Co., 123 Franklin St., Chicago.

BELMONT
"HYDRAULIC"
Style No. 8

is stitched through and through crossways; it can't swell, can't pinch, can't be twisted apart, can't do anything in fact, except stay right where it's put and keep the pump absolutely water tight with the least possible friction. Observe its construction—First, a core of finest braided flax, soft and tough.

Around three sides of this a casing built up of alternate layers of the best rubber and cotton duck, with the edges turned toward the rod, thereby insuring great durability. Then the cross stitching as described. Could anything be better? We think not, and the testimony of engineers who use Belmont Hydraulic No. 8 is that it's as near perfection as anything gets to be in this world below.

For every kind of pumping service and hydraulic machinery, and especially valuable when exposed to alkaline or sulphuric acid mine waters. Write for booklet C.

FREE Send for sample ring and be convinced. **FREE**

CLEMENT RESTEIN CO., Philadelphia, Pa.

Gentlemen:—Send me a sample ring of Belmont Hydraulic Packing, Style No. 8.

Name.....
Address: St. No.....City.....State.....
Firm Name.....
Number of Engines.....
Number of Pumps.....
Number of Boilers.....
High or Low Pressure.....
Packing now in use.....

Power, Nov. '08.

CLEMENT RESTEIN CO.,
133 N. Second St., Philadelphia, Pa.
Mfgrs. of every variety of packing and gaskets. General catalog on request.

Salesmen Wanted

To call at power plants, pumping stations and engine rooms and sell BELMONT PACKINGS and Specialties. Particularly attractive proposition for manufacturers, agents and engineers in territory not already covered.

CLEMENT RESTEIN CO., 133 N. Second St., Philadelphia, Pa.

Ambest
TRADE MARK

THE UNIVERSAL METALLIC PACKING
Takes the place of all others.

From the same can of **AMBEST** you can pack the largest piston rod or the smallest valve stem, whether for **steam, water,** or **ammonia.** For years it has been conceded that the only solution of stuffing box trouble lay in a metal packing. But people tried to use complicated arrangements of rings and springs and found them unsatisfactory. **AMBEST** is composed of long pliable lubricated filaments of non-friction metal. It is **simple, adaptable, universal, in its uses,** as **frictionless as oil,** and as durable as iron. Once placed in position, it's **there to stay.** Lasts months where fibrous packings last days. Every engineer who tries it, says **"It's the best packing ever made."**

Good live agents wanted everywhere to sell our AMBEST METALLIC PACKING direct to engineers. Write at once to secure the best territory.

FREE

.....(Fill out this coupon and mail to us).....

CANFIELD MFG. CO., Philadelphia, Pa.

Gentlemen:—You may send me, free of all charge, a sample of Ambest Metallic Packing.

Name.....
Address.....
Firm Name.....
No. of Engines.....Total h. p.....No. of Pumps.....
High or Low Pressure.....Packing now in use.....

POWER, Nov. '08.

CANFIELD MFG. CO., Philadelphia, Pa.

DON'T GIVE UP

if the packing you are using at present *blows out* and *wears out*. Try **Bristol Hydraulic Packing** and cease having packing troubles. **Bristol Packing** is made to stand the highest pressures. It lasts longer than other packings and never fails Write for details and prices.

National India Rubber Co.,

Factory, BRISTOL, R. I.

BRANCHES: 42 Broadway, New York. 84 Lake St., Chicago.
140 Essex St., Boston. 37 Hopkins Pl., Baltimore. 379 Washington St., Buffalo.

High Grade Packing

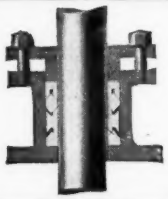
Johnson Packings are first MADE TO WEAR. Many other brands are FIRST MADE TO SELL. Pack the worst joint in your place with Johnson Packings and prove our claims. Catalog?

THE HENRY JOHNSON COMPANY,
175-187 Gates Avenue, Jersey City, N. J.

"Tauril" ¶ Can be used repeatedly—forty times if desired.
"Tauril" ¶ Will stand nearly as long as your machinery lasts.
"Tauril" ¶ Has a tensil strength of over three tons per square inch.
Use it where others have failed.

THE ANCHOR PACKING CO. TRADE MARK

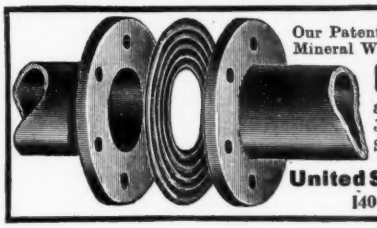
THE ANCHOR PACKING CO., - - PHILADELPHIA, PA.



VERY SIMPLE

To apply Law Improved Metallic Packing, it is not necessary to have special stuffing boxes or to alter existing ones. No springs are used.
Write for circular.

Houchin-Aiken Company,
Sole Manufacturers,
113-121 Fifty-Third St., Brooklyn, N. Y.



Our Patented Mineral Wool **Pipe Covering and Copper Gaskets** Save Steam and Make Absolutely Tight Joints. Best and Cheapest. Samples Free.

United States Mineral Wool Co.,
140 Cedar Street, New York

It Lasts For Years Without Attention

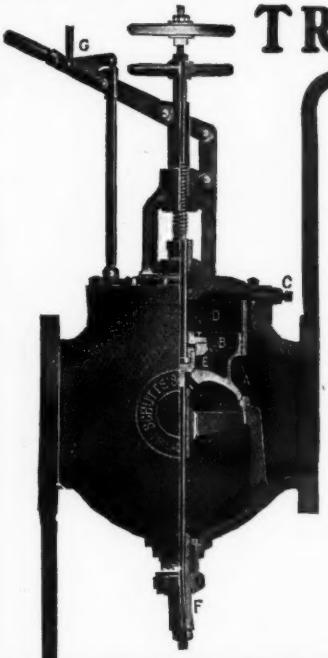
A joint packed with the Goetze's Elastic Gasket stays tight under the highest pressure of superheated steam and is not even affected by sudden changes of temperature.

Ask for a free sample giving size and purpose.

American-Goetze Gasket & Packing Company,

525 East 149th Street,
New York City.

SCHUTTE QUICK CLOSING BALANCED TRIP VALVE



These valves fill the requirements of Emergency shut-off valves. They are single seated. The valves are locked open by moving hand lever up till it catches in the latch supported on the upright bar. The steam pressure acts on the area of the pistons with a continuous downward force, which causes the valve to close when the latch is released. A hand lever attached to rod H, and same rod extended to any desired location, will permit the valve to be mechanically operated promptly, and without effort.

Write for catalog 8-D.

SCHUTTE & KOERTING CO.
Tompson and 12th Sts., Philadelphia
New York, Boston, Chicago, Pittsburg.
O. C. Goeriz & Co., San Francisco.

Nelson Valves

The Essential Merit

In the last analysis, the essential merit of a valve lies in the satisfaction rendered. The valves that endure without fault the rigid tests of inevitable hard service, prove their superiority without further comment; therefore many careful valve users specify Nelson Valves simply because they know, from experience, what they accomplish.

Nelson Valves are made in the Gate, Globe, Angle and Check types, in all sizes, of Iron, Bronze or Steel, for all pressures, for any service.

The Nelson Valve Company
Philadelphia

New York, Hudson Terminal Bldg.
Chicago, - 40 Dearborn Street
Pittsburg, - 525 Third Avenue
Minneapolis, - 622 Andrus Bldg.
San Francisco, - Atlas Building
Butte, Mont., - 56 E. Broadway

VALVES

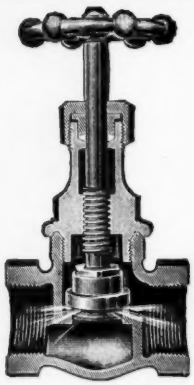
Makes no difference what kind of a Valve you want, how you want it made or where you want it shipped, we can supply it on shortest possible notice.

We manufacture valves and pipage equipment of every description, for all kinds of plants, Steam Separators, Tuyere Cocks, Brass Unions, Etc. Also make Pipe Bends, and do all kinds of Pipe Fitting, either assembled or ERECTED.

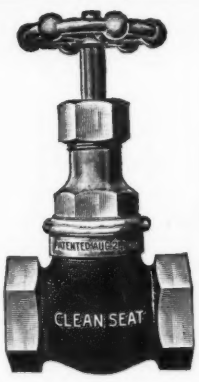
SEND FOR CATALOG

PITTSBURGH VALVE FOUNDRY & CONSTRUCTION CO.

Pittsburgh Cleveland New York Boston Birmingham, Ala.



CLEAN-SEAT VALVES



ARE BEST WE SAY SO, AND CAN PROVE IT:

1. A VALVE tightly closed does not wear fast.
2. A VALVE cannot close tight on a dirty seat.
3. A VALVE should be able to keep its seat clean.
4. A VALVE which can do this will wear well.

THE CLEAN SEAT VALVE, every time it closes, throws a strong jet of steam directly across the seat, all the way round, as the disc approaches the seat. This jet blows away all sediment, scale, grit, rust, or other foreign matter, and insures tight closing *every time*, by clean metallic contact between disc and seat.

The "Clean-Seat" principle reduces the wear on seats and discs to a positive minimum and makes easy the ordinarily difficult work of controlling high pressures. For high pressure service this valve makes its most conspicuous showing, and it is made in the following heavy weights:

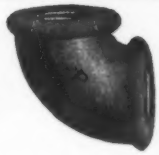
Medium for pressures up to and including 200 lbs.
Extra heavy for pressures up to and including 500 lbs.
Hydraulic for pressures up to and including 3,000 lbs.

For long, hard and continuous service the "Clean-Seat" Valve has no rival. On this claim, we stand ready to submit conclusive proof, beyond even a reasonable doubt.

PRICES:

Size.....inches	⅛	¼	⅜	½	¾	1	1¼	1½	2	2½	3
Medium.....each	1.10	1.10	1.25	1.60	2.20	2.80	4.00	5.50	8.75	15.75	22.00
Extra Heavy. "	.....	3.00	3.50	4.00	5.00	6.50	8.25	11.00	16.00	33.00	45.00
Hydraulic... "	.....	5.00	5.00	6.00	7.50	10.00	12.50	16.50	24.00	50.00	65.00

PITTSBURGH GAGE & SUPPLY CO., Pittsburg, Pa.



You Cannot be Interested in Power Plant Equipment

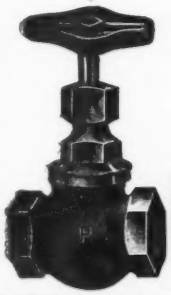
Unless you are Interested in

"P" VALVES and FITTINGS

Because We Claim Them To Be The Finest Product of Their Kind.

ALWAYS SPECIFY **P** VALVES and FITTINGS

ALWAYS SPECIFY **P** VALVES and FITTINGS



PITTSBURGH VALVE AND FITTINGS COMPANY,

General Offices and Works, BARBERTON, OHIO.

WE MANUFACTURE ALL KINDS OF VALVES AND FITTINGS. WRITE FOR CATALOGUE.

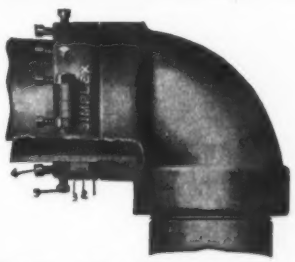
HERE YOU ARE! Just what you need to reduce those coal bills; the Mason Reducing Valve. It reduces and maintains air, steam or water pressure at any point, regardless of variations in initial pressure. Set and locked by key. Write for Catalog.

The Mason Regulator Co., Boston, Mass.

Erwood Swing Gate Valves

Manganesite Paste for Joints

WALCH & WYETH, 87 Lake St., Chicago.



THE WORST JOINT IN YOUR PLANT

can be made absolutely and permanently tight, provided you use the Simplex Pipe Clamp. Why allow your plant to bleed to death? WRITE!

THE SIMPLEX ENGINEERING CO.,
326 Preston Street, PHILADELPHIA, PA.

EVERLASTING BLOW-OFF VALVE

Straight-through flow. No stuffing-box. Easily operated. Self-cleaning; self-grinding seats. No repairs needed. Send for descriptive booklet and prices.

SCULLY STEEL & IRON CO.,
CHICAGO.

THE HIGHEST ORDER OF VALVE MAKING

is shown in **Homestead** Valves.

They excel in workmanship, quality, *never failing efficiency* and durability. The seats are positively protected from wear. Made in Straightway, Three-way, Four-way, Locomotive Blow-off, Angle Styles, etc.

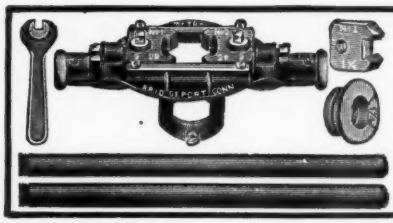
Catalog free.

Homestead Valve Mfg. Company,
Pittsburg, Pa., U. S. A.

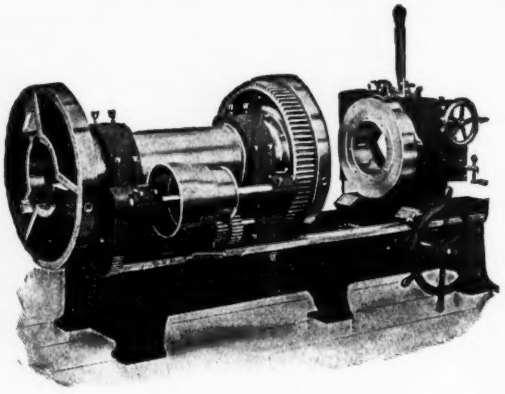
SENTINELS OF SAFETY
ASHTON GAGES!

They are guarding the lives and property of thousands of others—why not yours?
Write for a catalog.

THE ASHTON VALVE COMPANY, Boston, U.S.A.
NEW YORK St. John's House, London, England. CHICAGO



STOCKS AND DIES
PIPE MACHINES,
PIPE CUTTERS,
VISES.
Manufactured by
The Armstrong Mfg. Co.
287 Knowlton St.,
BRIDGEPORT, CONN.



READ THIS!

"Foreman says that the machines cut the cleanest threads he has ever seen and while originally they have favored the installation of another make which they have been using for ten years, they now say they would not give the Bignall & Keeler for forty of the other make—the latter, too, is a very good machine."

Bignall & Keeler Mfg. Co.
Edwardsville, Ill.

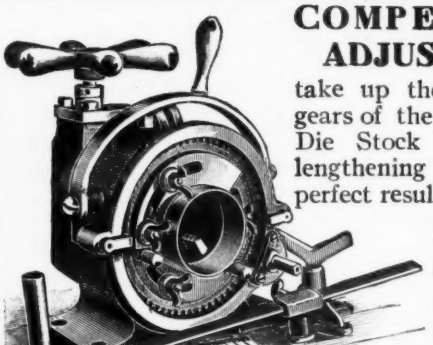
More Dies for Less Money

Being provided with a set of dies for each size of pipe the

Toledo Pipe Threading Devices

give many times the die service of any other similar tools. The Toledo proves to be far less expensive when compared with the inferior devices for threading pipe. Write.

THE TOLEDO PIPE THREADING MACHINE CO.
TOLEDO, OHIO, U. S. A.

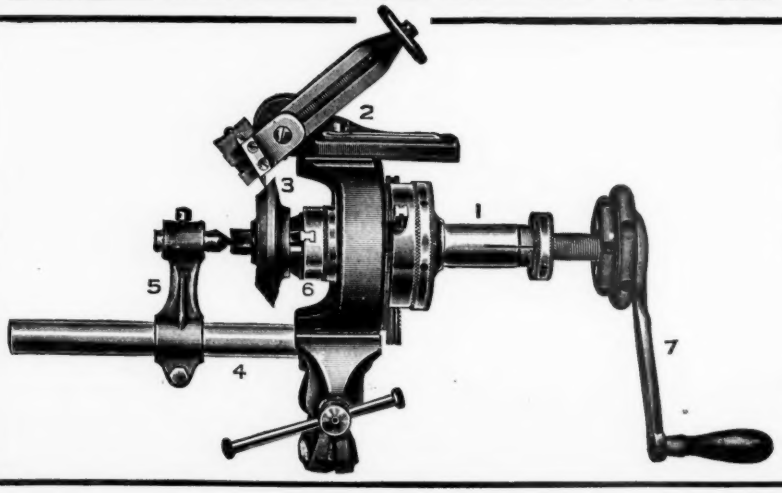


COMPENSATING ADJUSTMENTS

take up the wear on the gears of the Forbes Patent Die Stock thus greatly lengthening its period of perfect results.

Have the Circular?

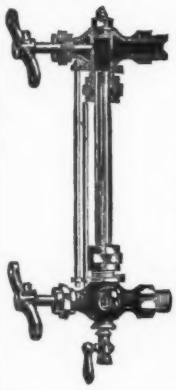
The Curtis & Curtis Co.
85 Garden St., Bridgeport, Conn.



There is no good reason for getting along without a **DEXTER VALVE RESEATING MACHINE.** "Can't afford it" or "the price" is no reason at all, for the machines pay for themselves. They often pay for themselves with valves from the scrap pile.

Catalog "P" For The Asking

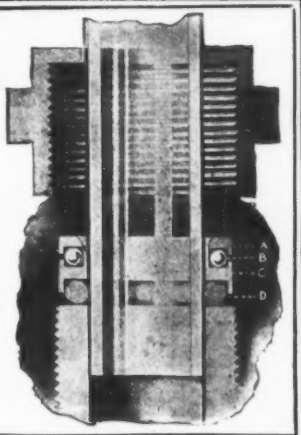
The LEAVITT MACHINE CO.
Orange, Massachusetts, U. S. A.



"OHIO" WATER GAUGE

Made from High Grade Bronze, Finely Finished, Quick Opening.

A NEW FEATURE is the Ball Bearing Gland, shown herewith. ¶ The Packing Nut comes in contact with Rotating Ring "A" which travels around without friction over balls "B," thus the Rubber Gasket "D" is relieved of all twisting no matter how tightly it is compressed and makes it possible to make an absolutely tight joint without breaking glass. *Full Description and Prices on Request.*



THE OHIO BRASS CO., MANSFIELD, OHIO, U. S. A.

NEW YORK 30 Church St. CHICAGO, 277 Dearborn St. SAN FRANCISCO, 138 Front St.

The Average Union Sticks

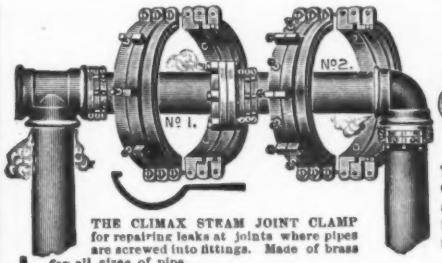
It rusts together. And what good is a union in the pipe line unless it can be disconnected? It's probably only good enough to throw away after you've forced it apart. **"KEWANEE" UNIONS** are made with a brass-to-iron thread connection and seal. Thus they can always be disconnected without the least trouble. WRITE!

"M. & F."

National Tube Co., Pittsburgh, Pa.

DISTRICT SALES OFFICES

Atlanta Denver New York Pitts'urgh St. Louis Salt Lake City
Chicago New Orleans Philadelphia Portland San Francisco Seattle



THE CLIMAX STEAM JOINT CLAMP for repairing leaks at joints where pipes are screwed into fittings. Made of brass for all sizes of pipe.

THE EMERGENCY PIPE CLAMP, for repairing splits and rust holes. Made of malleable iron from ⅛ in. to 12 inches.

PIPE REPAIRS FOR ANY CONDITION

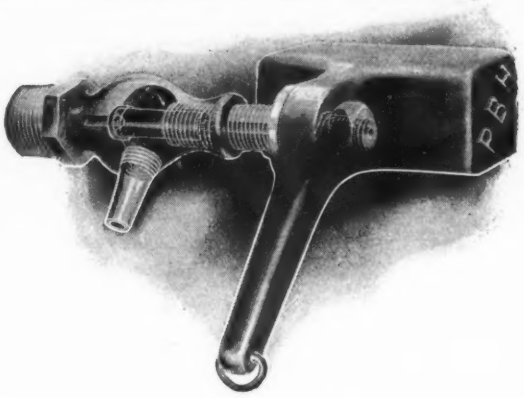
Send for Catalog of

STEAM SPECIALTIES

JAMES McCREA & CO.,

MANUFACTURERS,

61 West Washington Street, Chicago.



The Metal Pencil Lasts for Years

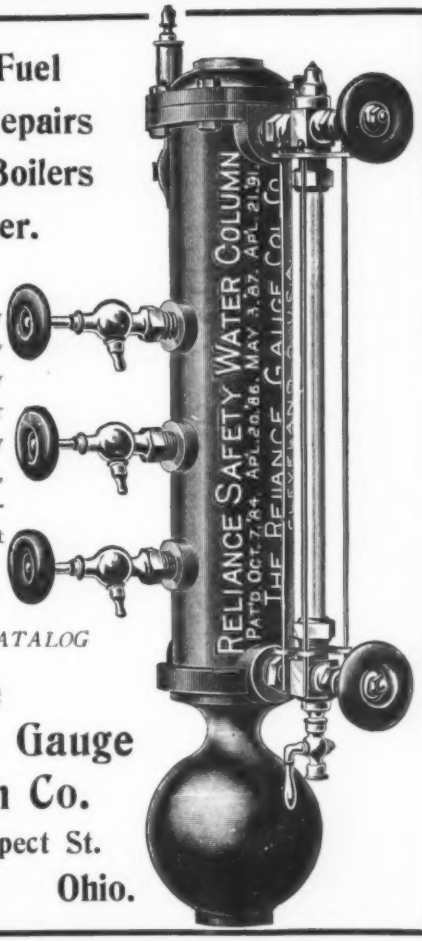
and then when it finally does wear out it can instantly be replaced at the trifling cost of a few cents. This valve pencil is the only wearing part about the **"P.B.H." Gauge Cock.** We guarantee the **"P.B.H."** leakless for years. Shipped to your plant on a 30 days' free trial. Write!

THE PAUL B. HUYETTE CO.

2025 BETZ BLDG., PHILADELPHIA, PA.

Saving of Fuel
Saving of Repairs
Saving of Boilers
Steady Power.

Reliance Safety Water Column *may* save your life by preventing a boiler explosion but they *will surely* save fuel, repairs and equipment and is not that enough?



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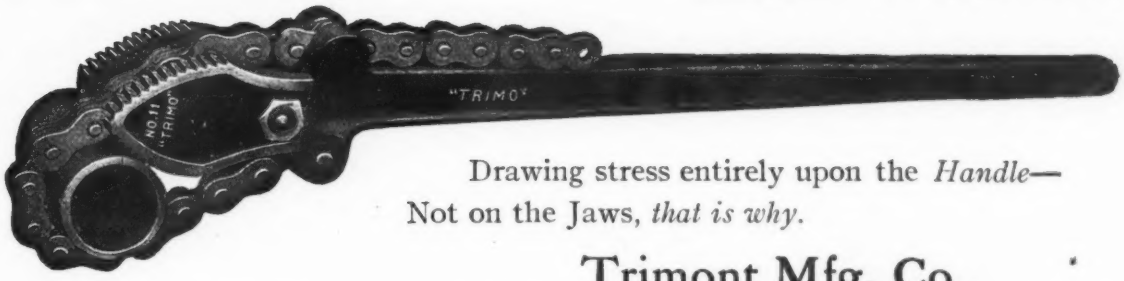

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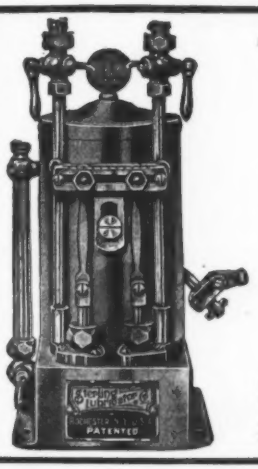

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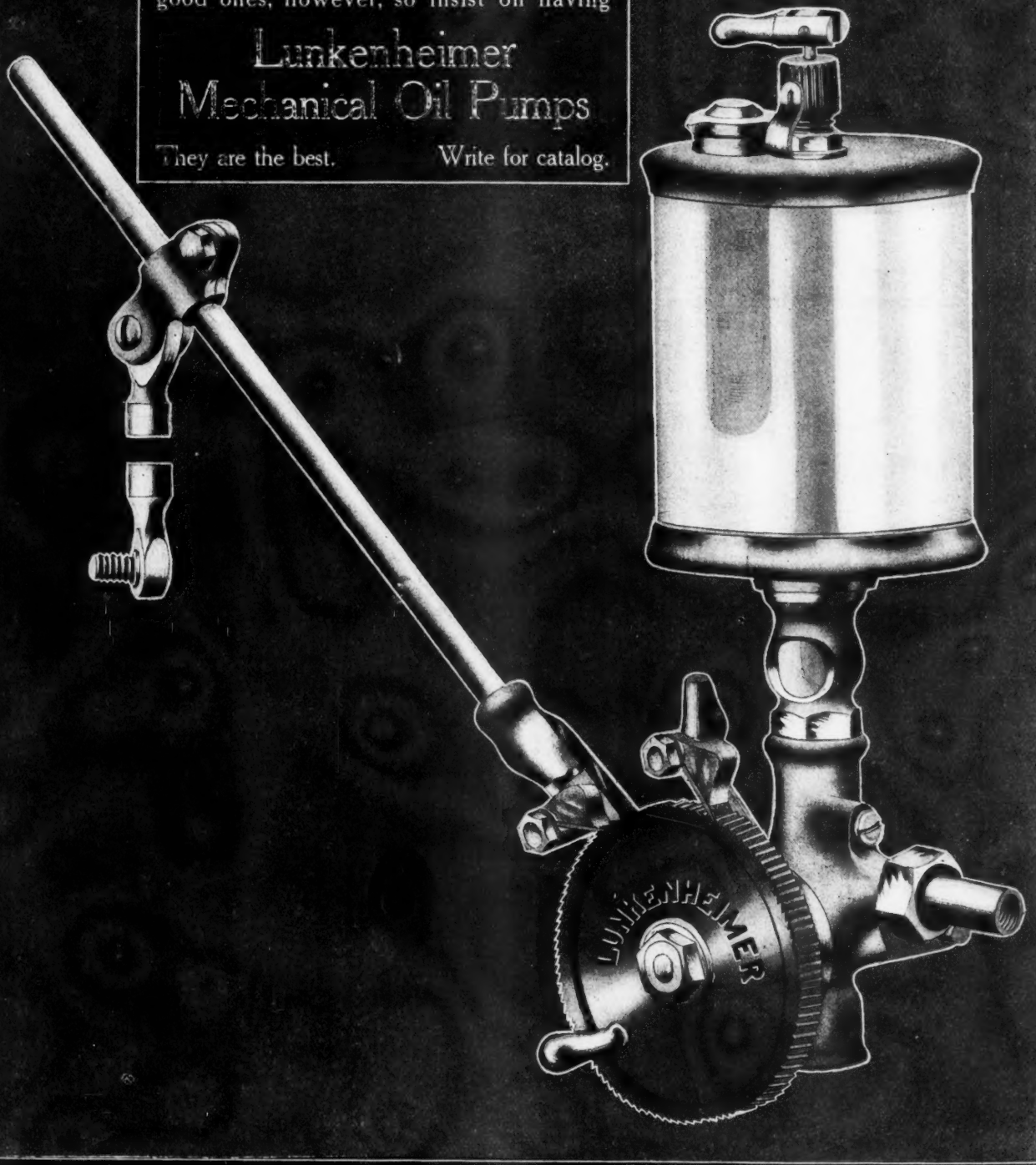

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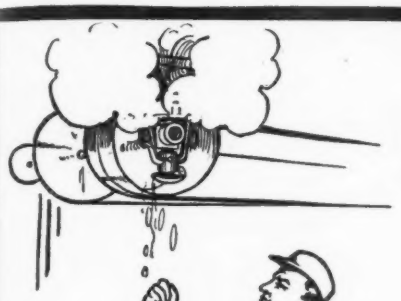

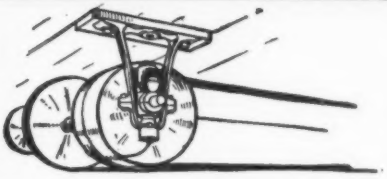

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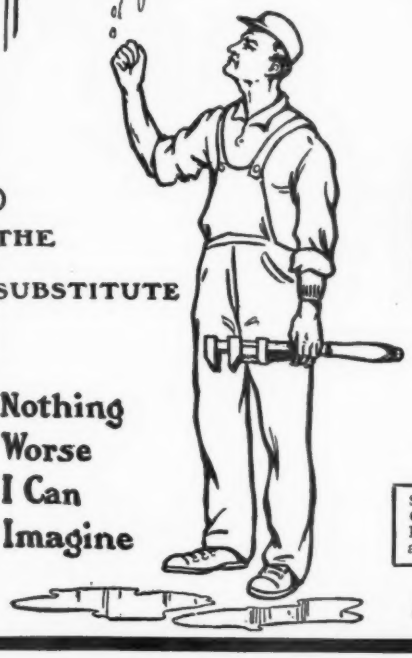

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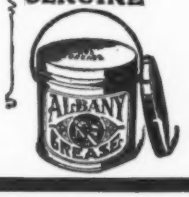

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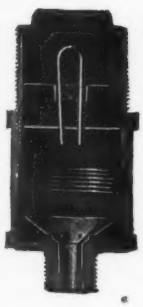

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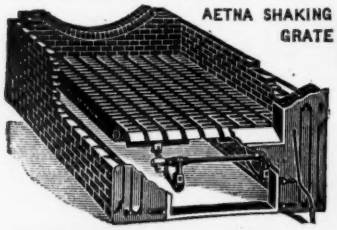

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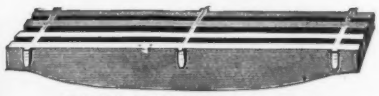
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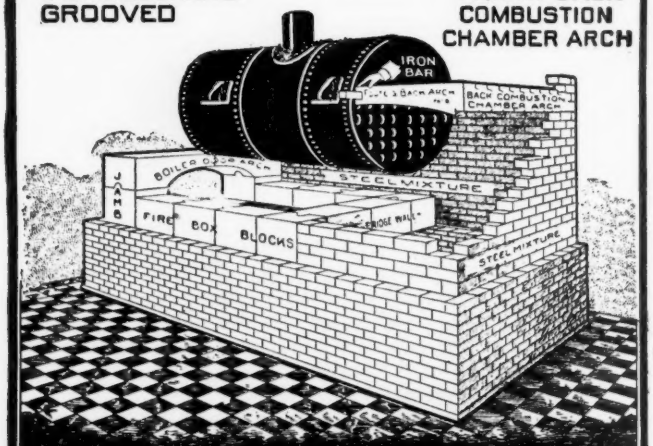

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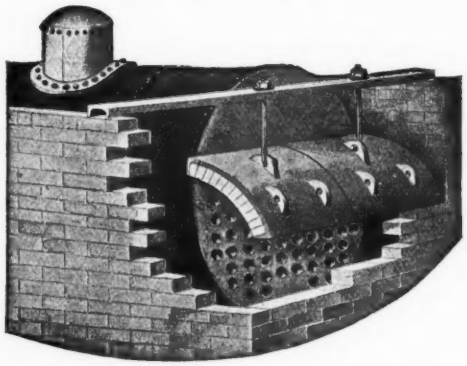

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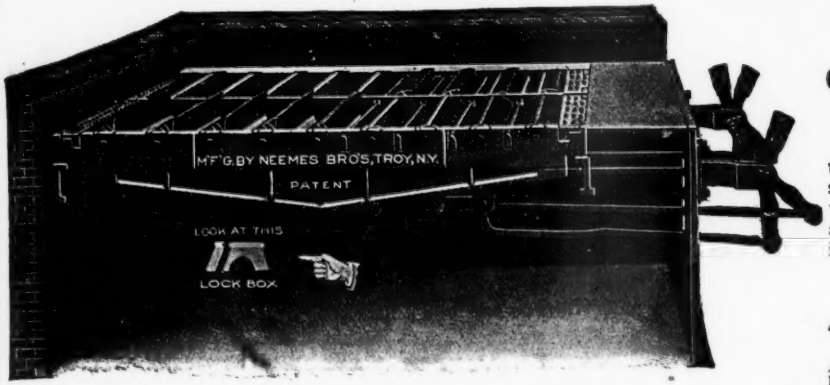

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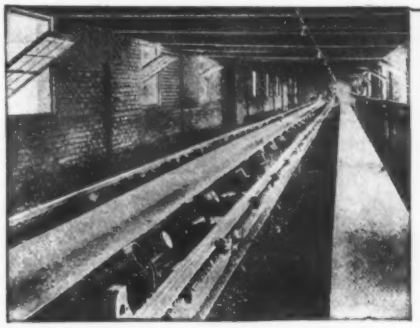

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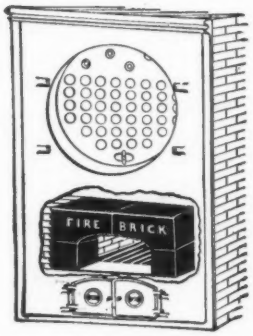

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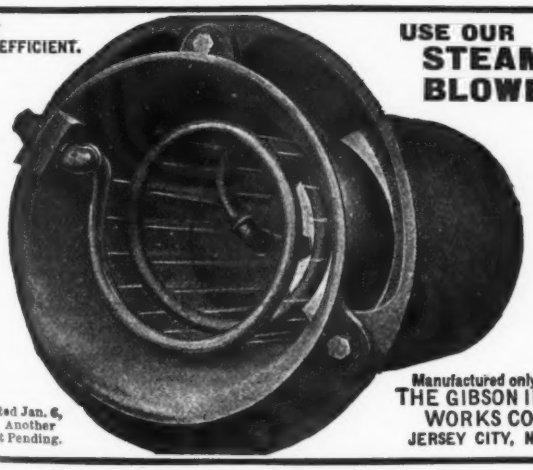

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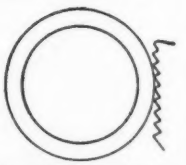

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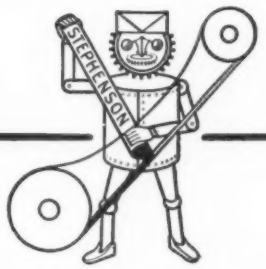

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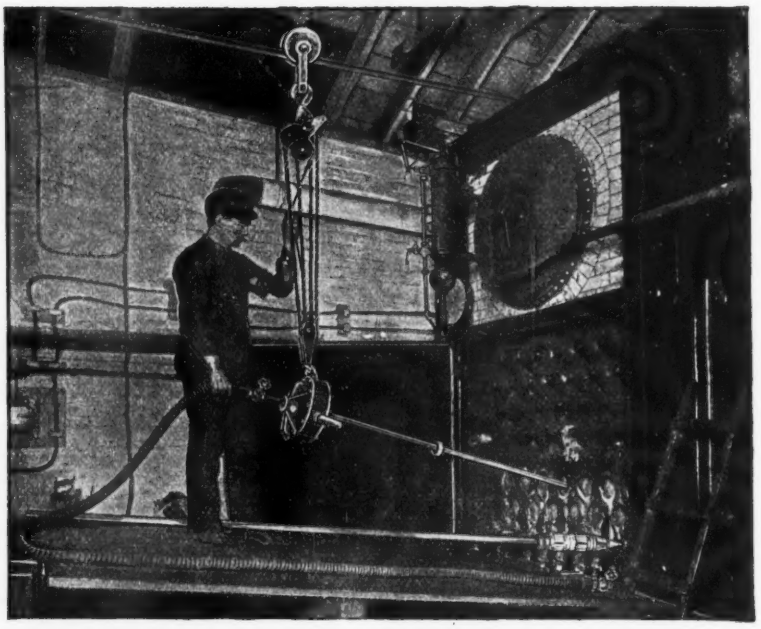
This one incident shows plainly *first*, that it is folly to neglect scale, and *second*, that water "purification" may not keep boilers clean. The one sure protection against obstinate scale is



Weinland Steam or Air Cleaner removing ½ inch scale from one tube every 8½ minutes, at the plant of Foos Mfg. Co., Springfield, Ohio.

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applied whenever conditions demand.

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These answer in a great many cases. They may do so in yours, but if your scale becomes very hard or accumulates rapidly, it can be removed more easily and economically with WEINLAND MECHANICAL CLEANERS than any others. This type of CLEANER has cleaned thousands of scale-filled tubes which would otherwise have been cut out, the saving alone in this way, paying many times the cost of a machine.

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Tell us the particulars in your case, and we can give disinterested advice, recommending machine best suited to conditions, and we can do it without bias, for we have more kinds and sizes of Cleaners than any other manufacturer.

Ask for book "Boiler Scale and Its Removal".

THE LAGONDA MFG. CO., SPRINGFIELD, OHIO

Makers of Weinland Cleaners, Lagonda Reseating Machines, Automatic Cut-Off Valves and Tube Cutters

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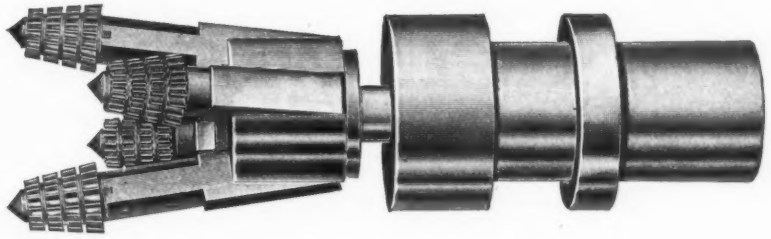
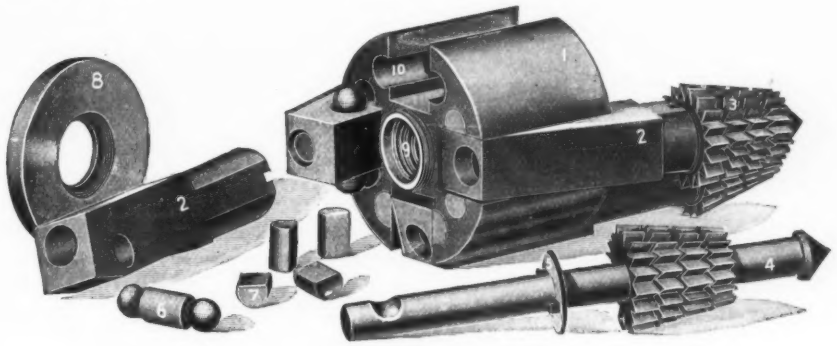


The "Cyclone" Cleaner

is the most satisfactory tool in existence for cleaning water tube boilers. It can be driven by either compressed *air* or *steam,* and is always "*Johnny on the spot.*" No time is wasted making repairs on either the motor or the cleaning head. The "Cyclone" reduces cleaning cost 75%. It is easy to handle and does not flood the boiler room or destroy the furnace brick work. Its invention makes boiler cleaning easy.



The motor is equipped with

The "Norivet" Head,

which is, as its name implies, a cleaning head held together *without the use of rivets,* all parts *being locked* in place. The "Norivet" is constructed in such a way that any part can be replaced by hand without the use of tools. Its construction is more powerful and more durable than any other cleaner head heretofore produced, and it is replacing all the other types of heads so rapidly that it taxes our capacity to keep up with the demand.

Suppose you stop and think of how much time you waste in cleaning boilers on account of the trouble you have in repairing your present cleaner head. Figure up the lost time and see how much you can save if you did not have a lot of rivets to take out and replace every few hours. After you have figured up the amount of time so lost you will appreciate the wonderful advantage of a cleaning head without rivets. Investigate it and you will adopt it.

LIBERTY MANUFACTURING COMPANY,

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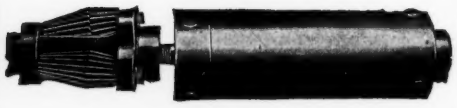
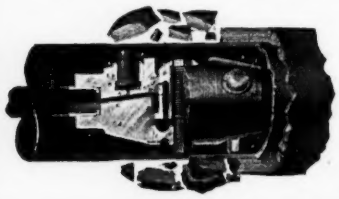
"THEY ARE THE BEST CLEANERS EVER MADE"



The "Demon" Water Tube Cleaner
(Made in special design for bent tubes)

A strong, powerful piston machine that makes the ordinary tube cleaner look like a toy.

We want every engineer, whether he now needs a new cleane or not, to write for our Circular No. 54, "Demon Cleaner vs. Other Cleaners," or Circular No. 56, "Demon Curved Tube Cleaner," if his boilers have bent tubes.



The "TORPEDO" is the ideal type of fire tube cleaner. It was designed and operates solely for the removal of scale on the outside surfaces of boiler tubes. It is a vibrator—*not* a hammer machine. Send for one on free trial and if it doesn't do even better work than you expect send it back. Don't fail to read Circular No. 30, "How To Tell A Good Fire Tube Cleaner."

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which, by taking a continuous record over a considerable period of time, shows the average instead of the merely momentary conditions.

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has an outside spring, strong enough to get the drum back into place before the beginning of the next stroke. It takes a six-foot strip of paper which can be renewed without removing the indicator from the engine.

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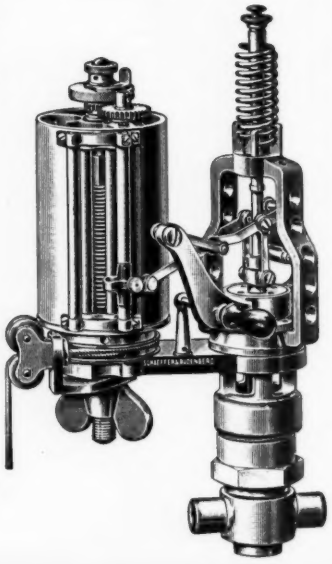

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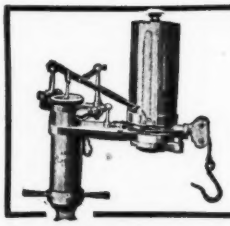

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and all other standard indicators cost at least $50 more than the Trill. *Write.*

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is possible only where scale troubles are eliminated. Pyramid Boiler Compound is the only sure eliminator. Write.

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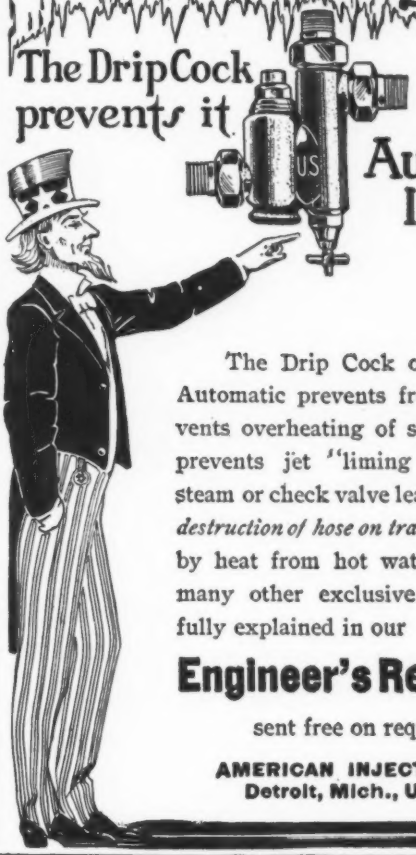
The Drip Cock prevents it



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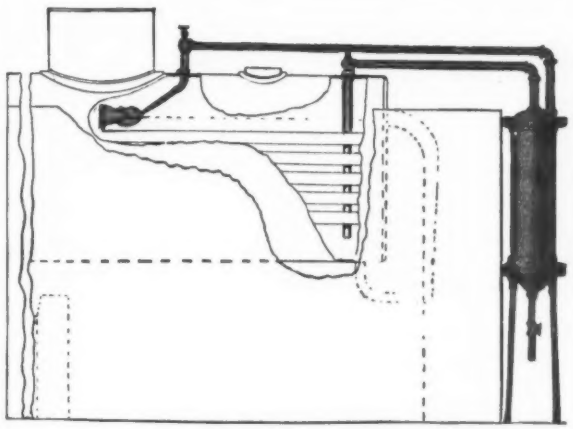

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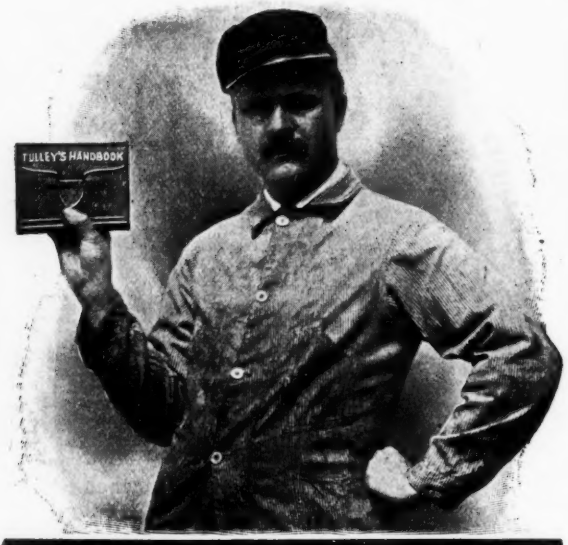

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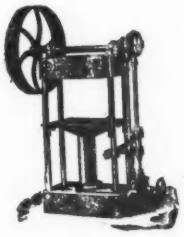

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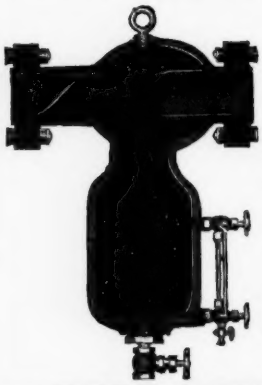

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absolutely separate all water from the steam without the use of baffle plates and without an ounce loss of pressure.

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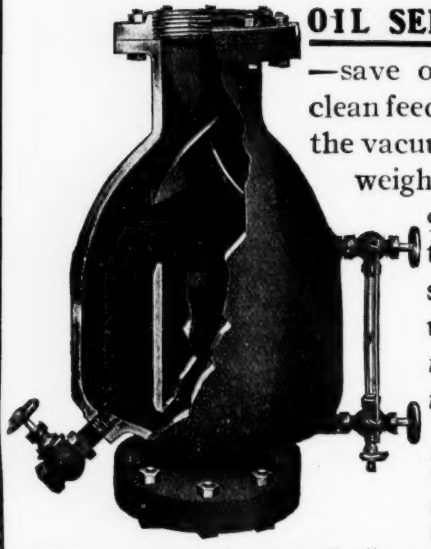

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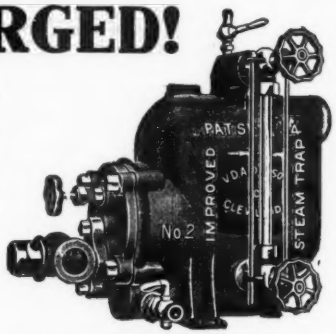

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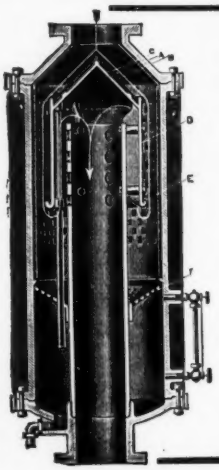

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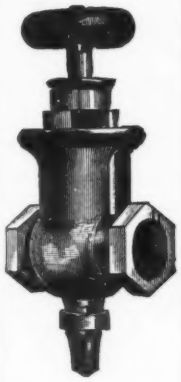

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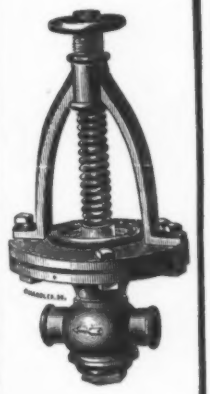

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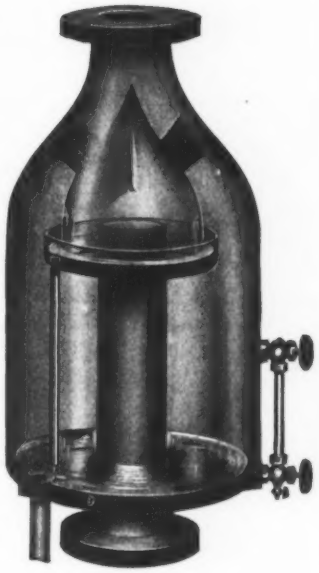

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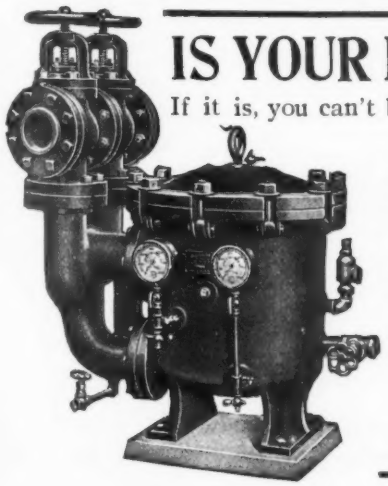

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THE BLACKBURN-SMITH FEED WATER FILTER AND GREASE EXTRACTOR

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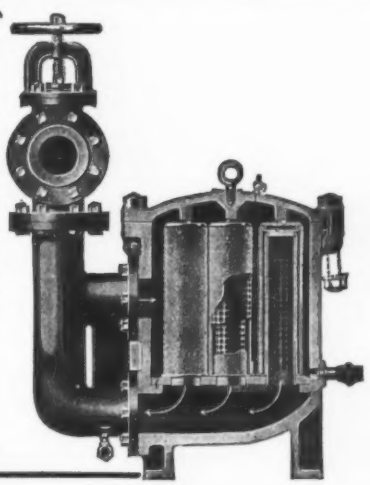

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KITTS MFG. COMPANY,
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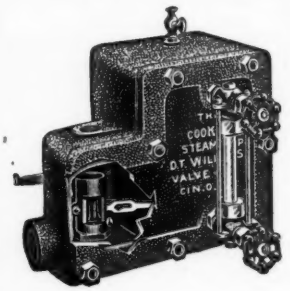
Judge a Trap By Its Simplicity



THE steam trap question is an important one for the engineer or steam fitter and should be carefully considered. It is a well known fact that a trap that is complicated in construction is more liable to get out of order and give more trouble than one which has the advantages of simple construction. Simplicity means reliability and durability. They are the elements which make a successful steam trap.

The Cookson Low Pressure Trap

is simplicity itself. Of few working parts, the valve is of the single seated type—is perfectly balanced, and is very sensitive to large slugs of water, which it readily discharges without any loss of steam. Perfectly automatic in its action, it has no equal for draining Exhaust Lines, Fan Coils or Heating or any other Systems working on 30 pounds pressure or less. If you want *steam trap satisfaction*—you need a Cookson trap.

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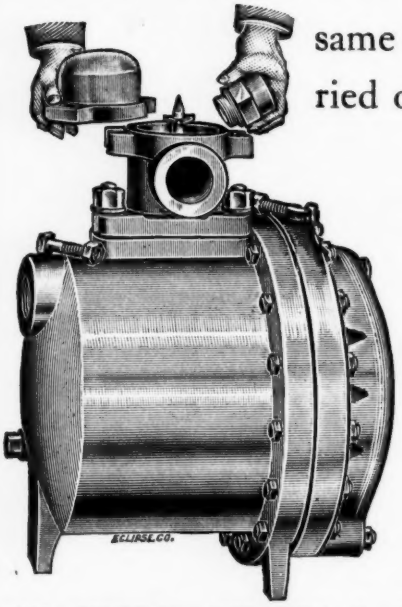
same idea is carried out in all of



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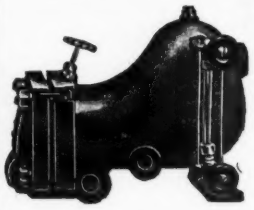
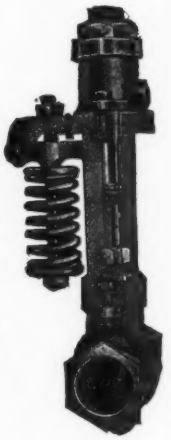


McDANIEL STEAM TRAPS

are especially adapted for draining steam separators and high pressure mains. Also good for steam heating. All working parts are attached to the bonnet, and are removable with it. Valve outlets are large, to give rapid discharges of condensation.

Watson Steam Pump Governor



should be used on all steam pumps where a fixed discharge pressure is desired.

The construction permits of easy access to the stuffing box for removing packing, and the spring can be adjusted or entirely removed without interfering with any other part of the valve. Any practical man will readily see its advantages.

All our goods are made in our own factory and tested before shipping. We guarantee them to give perfect satisfaction. Established 1878.

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Make The Exhaust Steam Earn Money

The Loew Feed Water Heater gives to the exhaust steam a *moneyed value* which no sane power man can afford to lose. It reduces fuel bills 15% and has advantages no other feed water heater possesses.

The water is thoroughly mixed and passes *six times* through the exhaust steam. The cleaning operation is simple and is quickly over. Due allowance is made for expansion and contraction.

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Send us your name and address on a postal and we'll send you full particulars regarding the **Morehead Steam Trap.** This trap is unlike all others. We want to place our Catalog in your hands and have you read it from cover to cover. It will open your eyes.

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OF PLEASED CUSTOMERS TESTIFY TO THE MANY ADVANTAGES OF THE **GEIPEL STEAM TRAP.** LET US SEND YOU ONE ON TRIAL.

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Costs Little Saves Much

There is no known method of freeing steam pipes from water that is so simple or as effective as by use of the

MARCK STEAM TRAP

THIS TRAP CAN BE USED WITH THE LEAST POSSIBLE ALTERATION TO YOUR PRESENT SYSTEM, inasmuch as it can be installed in any position.

The best evidence of the truth of our assertion is the fact that there are

Over A Million In Use

and in many of the large industrial establishments and mines, this trap is carried in store in the store rooms the same as ordinary valves.

SENT ON 30 days' approval. GUARANTEED FOR TWO YEARS.

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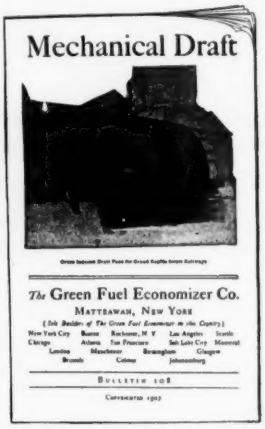
A Green Mechanical Draft Plant

will give better combustion and less smoke from any fuel or cut down the cost of fuel by utilizing a cheaper grade. Few boiler plants are put in where there is not a probability that the plant will at some future time be increased. This can be done by speeding up the Green Mechanical Draft Fan. Where a high rate of combustion is needed for only a short time during the day, as in traction plants, or for a few weeks of cold weather in winter, the Green Mechanical Draft plant will meet the unusual demand with ease and at the expense of only a slightly greater amount of steam for driving the fan engines. With a Green Mechanical Draft Out t a larger quantity of coal can be burned per square foot of grate with less excess of air, thereby raising the furnace temperature and increasing the economy. Low fires can be brought up as quickly as desired. A Green Mechanical Draft Fan is unaffected by temperature or barometric conditions. A Green Mechanical Draft Fan can at any time be sold or moved to a new location without serious loss.



A Green Mechanical Draft Outfit will enable you to utilize your boiler plant, your engine plant and your Fuel Economizer to the fullest advantage and capacity. Before proceeding further with your boiler station plans, send for the above booklet, in which all these matters are fully explained and which contains descriptions and illustrations of all systems of forced and induced draft, including a dozen different lay-outs. We have had experience in the construction and operation of a large number and variety of installations. In studying a plant with a view to putting in a mechanical draft outfit or an economizer, we first obtained full details as to conditions, space available, cost of fuel and water, etc., and our advice to the purchaser is based upon these facts and is put into such shape that he will know before hand the extent of the saving. No charge is made for this service. Ask for Booklet "108P" and also for our new Fan Catalog

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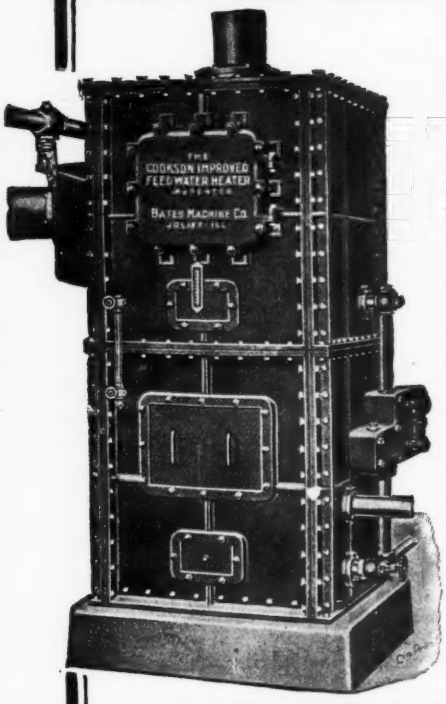
New York City, Boston, Chicago, Atlanta, San Francisco, Los Angeles, Seattle, Salt Lake City, Montreal.

Engineers: Builders of Green's Fuel Economizers, Fans, Blowers and Exhausters, Steam Air Heating Coils, Waste Heat Air Heaters, Mechanical Draft, Heating and Ventilating and Drying Apparatus, Draft Dampers and Engines. 136

COOKSON STANDARD ALL CAST IRON FEED WATER HEATERS



Highest Temperature and Positive Purification of feed water.

Perfect Separation and Removal of Oil.

Automatic Control of Cold Water Supply.

Dry Steam for Heating Purposes.

Finest Grade Special Fittings.

Lime Catching Pans. Especially Adapted for use with Heating Systems, Dryers, Etc.

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Sole Manufacturers **Joliet, Illinois**

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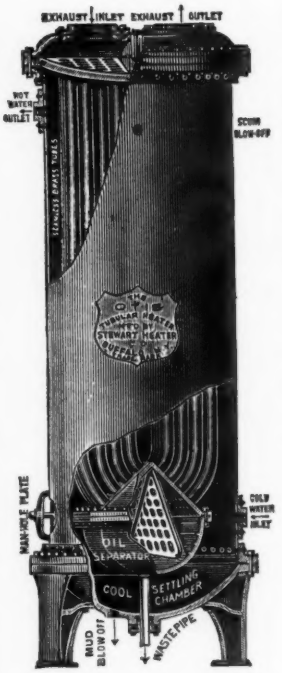

You may buy all the tube cleaners made and enough boiler compound to swamp your plant but, why do it when The Otis Feed Water Heater and Purifier costs less, does more and does it better ?

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THE STEWART HEATER COMPANY

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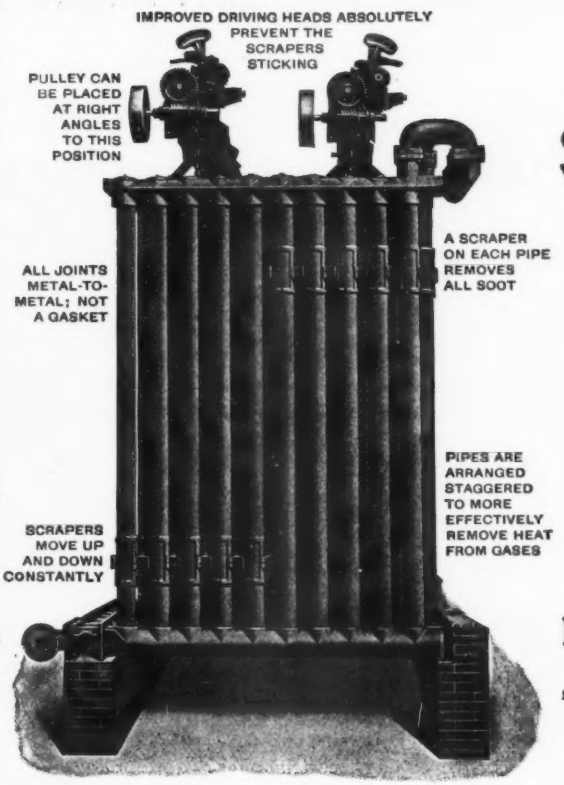
IMPROVED DRIVING HEADS ABSOLUTELY PREVENT THE SCRAPERS STICKING
PULLEY CAN BE PLACED AT RIGHT ANGLES TO THIS POSITION
ALL JOINTS METAL-TO-METAL; NOT A GASKET
A SCRAPER ON EACH PIPE REMOVES ALL SOOT
PIPES ARE ARRANGED STAGGERED TO MORE EFFECTIVELY REMOVE HEAT FROM GASES
SCRAPERS MOVE UP AND DOWN CONSTANTLY

OUR ENGINEERS will explain in detail the

Sturtevant Economizer

and help you plan the BEST INSTALLATION for Utilizing the Heat now Escaping from your stack.

Built for Pressures up to 300 pounds per square inch.

Can be used with a Chimney or with **Sturtevant Mechanical Draft** Apparatus.

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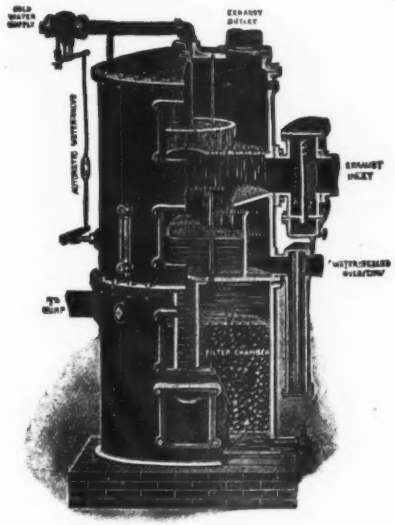
701

THE WHITLOCK OPEN EXHAUST Feed Water Heater and Purifier



Perfect Oil Separation. Easily Cleaned. The Highest Possible Temperature in the Feed Water.

Manufactured by

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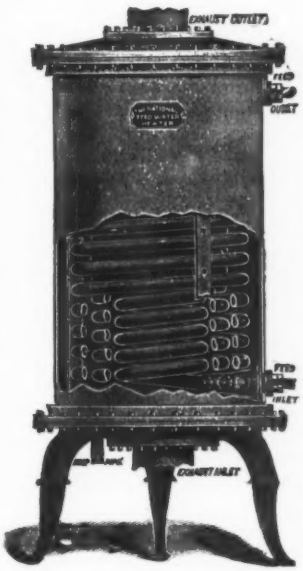

You don't see any inside joints or straight tubes to leak. No contact of the water with shell. No back pressure. No freak features. Nothing complicated to get out of order.

Nearly a million H. P. NATIONAL FEED WATER HEATERS are in use today.

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Harrisburg Feed Water Heaters

Of Pure Seamless Copper Coils. Guaranteed to be the most effective, most durable and cheapest heater manufactured.

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Manufacturers of HIGH GRADE

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BLACK AND GALVANIZED

Every Coil a Spring

Reilly Multicoil

FEED WATER HEATER

IN AN ADVERTISEMENT we cannot describe all the advantages of this heater. We therefore ask you to write for our Catalog.

The GRISCOM SPENCER CO.

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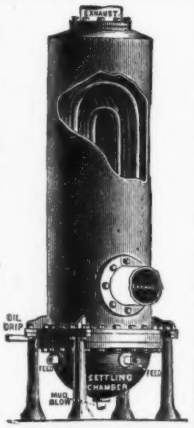
Almost Boils Feed Water

and requires no more steam than the less efficient heaters.

Patterson-Berryman Feed Water Heater and Purifier



is easier to clean or repair and requires less cleaning and fewer repairs than any other device for the purpose.

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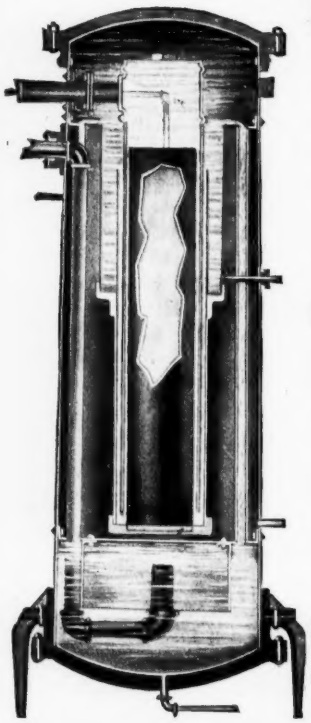

Feed Water

will prove a greater economizer in your plant than all the compounds and tube cleaners in existence.

The Eclipse Feed Water Heater & Purifier

gets at the root of the trouble by removing the cause of scale. Let us tell you the advantages of heating with live steam.

The Eclipse Feed-Water Heater & Purifier Co.,

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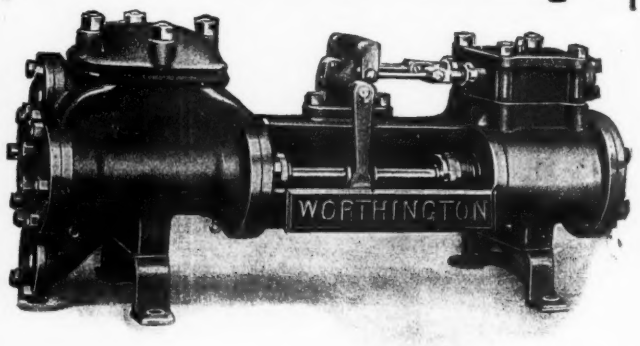

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is on Your Pump it Means

BEST WORKMANSHIP MATERIAL DESIGN SATISFACTION

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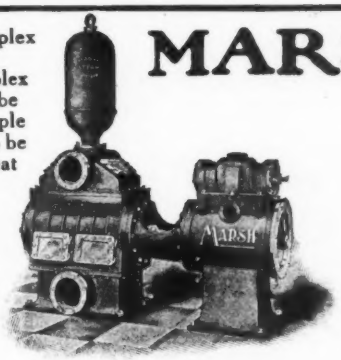
Works, Harrison, N. J.

Simplex Not Duplex To be Simple is to be Great



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are designed for handling hot as well as cold water. They are *at regular prices* fitted with bronze Piston Rods, bronze Water Cylinder Liners held in place by Studs, bronze Valve Seats, Stems, Nuts and glands. THE BEST OF MATERIAL AND THE BEST OF WORKMANSHIP ONLY GO INTO **MARSH PUMPS.**

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Goulds Efficient Power Pumps

are growing in favor wherever they are installed. Let us send you Catalog of Pumps for every service.

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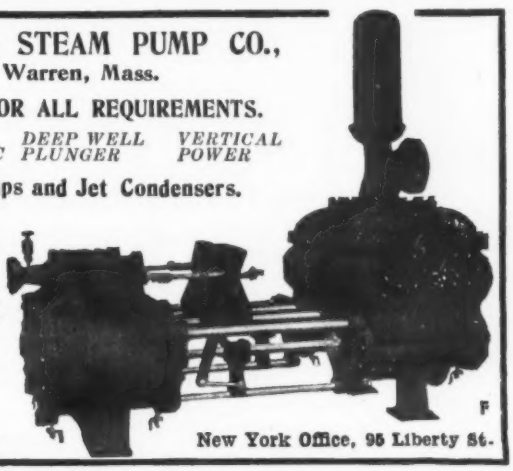
PUMPS FOR ALL REQUIREMENTS.

PISTON HYDRAULIC *DEEP WELL PLUNGER* *VERTICAL POWER*

Air Pumps and Jet Condensers.

Combined Air and Circulating and Marine.



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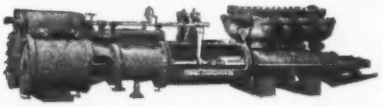
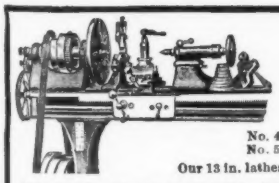


Epping-Carpenter Co., - - Pittsburg, Pa.



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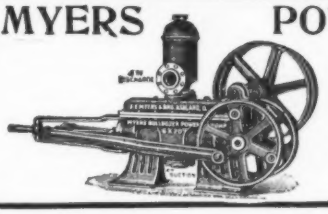

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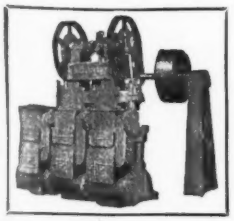

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Simple and Duplex Boiler Feeders. Jet and Surface Condensers. Power and Electric Pumps.

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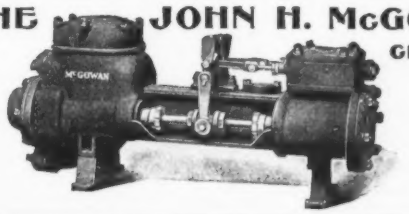

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This pamphlet discusses the adaptability of different condensers, jet, barometric and surface, to various conditions and classes of work, and explains the economies of running condensing. It describes the best types of surface condensers, including the

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We build Wheeler Surface, Jet and Barometric Condensers, Wheeler-Volz Combined Surface Condensers and Feed Water Heater, Wheeler Feed Water Heaters, Barnard-Wheeler Cooling Towers, Wheeler-Edwards Air Pumps, Wheeler Centrifugal Pumps, Wheeler Rotative Dry Vacuum Pumps and Wheeler Multiple Effect and Evaporating Machinery). 21

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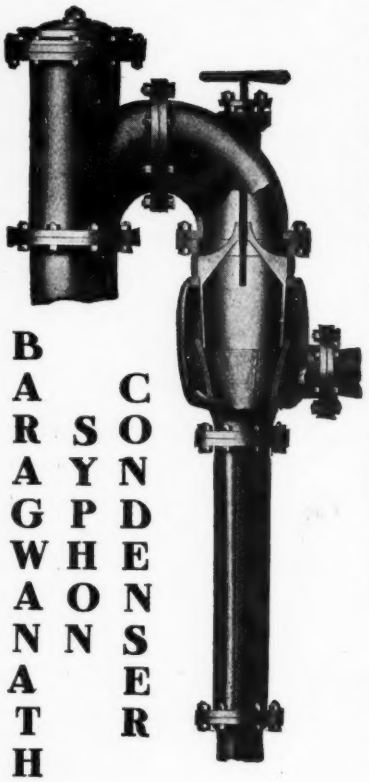

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of this type, our water nozzle is adjustable, thereby admitting of close regulation of the water supply, still maintaining the circular form as the stream of water enters the condensing chamber, and exposing the same large condensing surface.

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chosen by the best engineers because it prevents racing, works automatically, saves fuel, is simply constructed, and outlasts the best of other makes.

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Balanced by
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That's the simple and never failing principle upon which the Davis Pressure Regulator operates. It has no springs, toggles, diaphragm or auxiliary valves in its make up.

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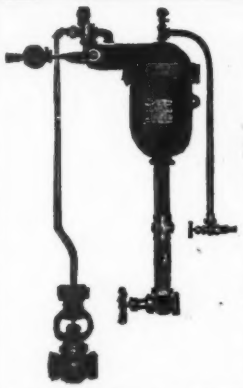

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Feed-Water Regulator

for steam boilers was the first in the *field*, and has the longest and best record of any of these devices.

Costs Less to Operate and Maintain

Constructed on a different and better principle than any other.

Investigate it and the

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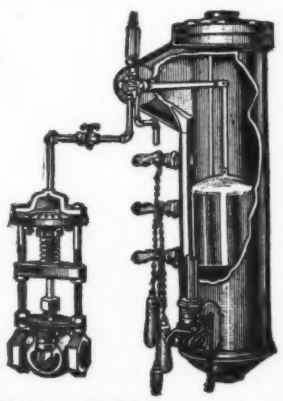
Safety
Automatic
Feed Water
REGULATOR



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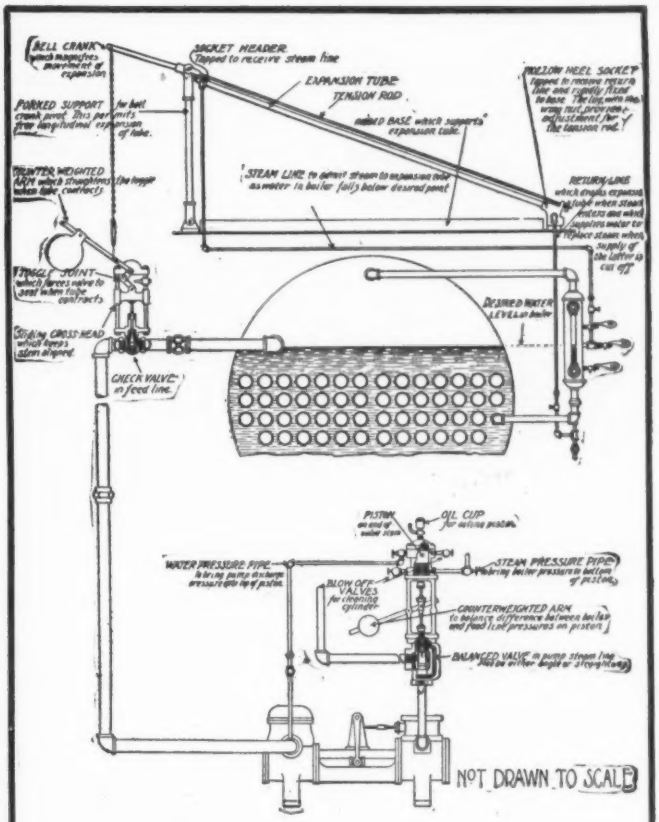
Philadelphia Office, 633 Bourse Building.



How The Copes Boiler Feed Regulator Works May Be Seen From The Diagram

How it protects boilers from the effects of low water and the engines and turbines from the effects of high water and helps the feed water heaters and economizers to save more coal is explained briefly and concisely in our New Catalog "P," which we would be pleased to send to you.

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American Boiler Economy Co.
PHILADELPHIA, PA.

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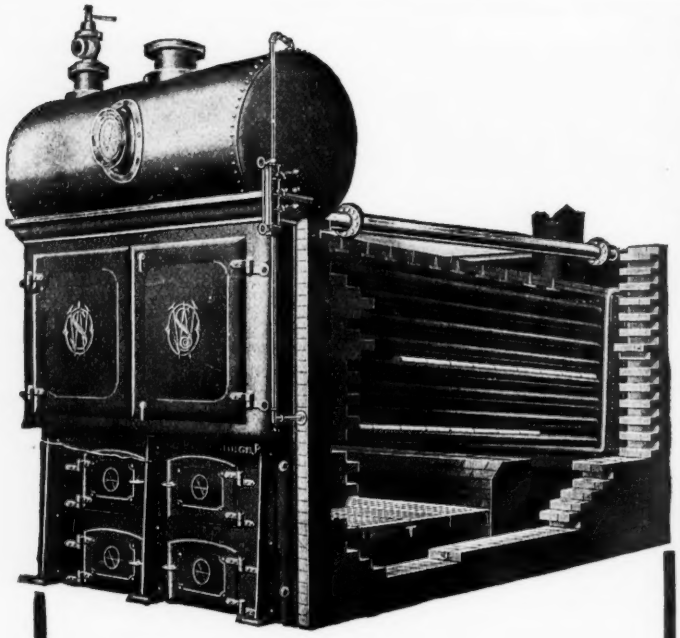

The Basis Of Economy

in any power plant is the boiler system. If you appreciate that fact you will do well to investigate

Our Safety Water Tube Boiler

Built for any pressure from 125 to 300 pounds. Meets all the high duty requirements of modern triple and quadruple expansion and compound engines. Perfect circulation, remarkable economy, and freedom to expand and contract, are features.

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Insure uniform stroke of direct acting pumps.

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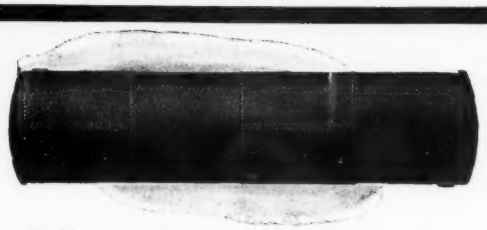


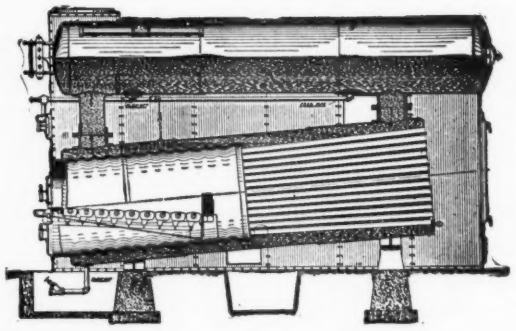
KEWANEE TANKS

We are the largest and best manufacturers of storage and pressure tanks in the United States. The story is told. See Book No. 51. Send your specifications.

KEWANEE BOILER COMPANY
KEWANEE, ILLINOIS.

Save Money by Buying a

ROBB-MUMFORD

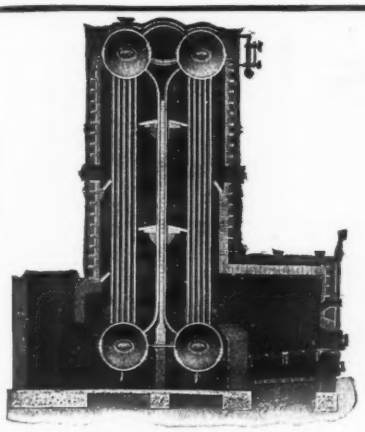


Internally Fired Boiler

Low first cost—Saving in fuel—Durable, Safe—Built in all sizes from 60 to 250 horsepower.

ROBB-MUMFORD BOILER COMPANY
SOUTH FRAMINGHAM, MASS.

New York Office, 90 West Street. Boston Office, 170 Summer Street.
Built in Canada by Robb Engineering Co., Ltd., Amherst, N. S.



TYPE B

THE RUST
WATER TUBE
BOILER

SAFE, SIMPLE, DURABLE,
ECONOMICAL, ACCESSIBLE

Write for Report of Tests by William Kent.

THE RUST BOILER CO.,
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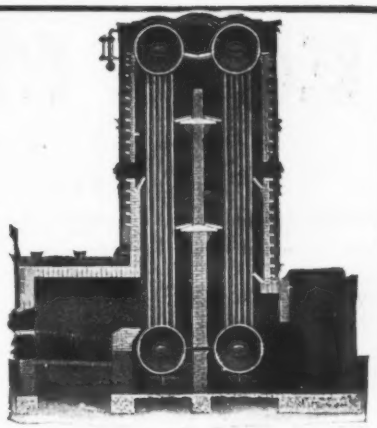
Branch Offices: New York, 50 Church Street; Birmingham, Alabama, First National Bank Building.



TYPE G

THE BABCOCK & WILCOX COMPANY
85 LIBERTY STREET, NEW YORK
WATER TUBE STEAM BOILERS
STEAM SUPERHEATERS—MECHANICAL STOKERS

Barberton, Ohio — WORKS — Bayonne, N. J.

BRANCH OFFICES

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MEXICO CITY—7 Avenida Jurez
HAVANA, CUBA—116½ Calle de la Habana
LOS ANGELES—Trust Building
CINCINNATI—Traction Building
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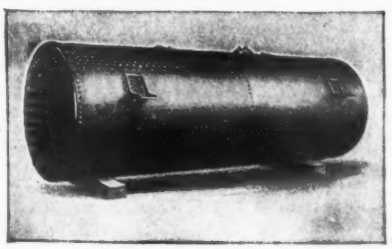

WICKES Horizontal Tubular Steam Boilers
HIGHEST GRADE

THE WICKES BOILER CO.

Also Manufacturers of the Wickes Vertical Water Tube Safety Steam Boilers
Main Office and Works, Saginaw, Mich.

SALES OFFICES:
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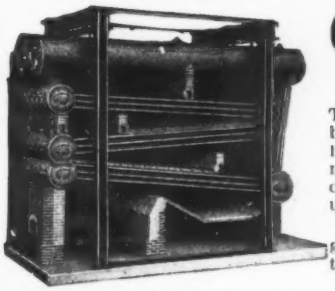
1139 AmericanTrust B'ld'g., Chicago, Ill.
Penobscot B'ld'g., Detroit, Mich. Empire B'ld'g., Pittsburg, Pa.
601 Brown-Marx B'ld'g., Birmingham, Ala.

WE HAVE NO USE FOR CAST IRON



In making the Vogt Water Tube Boiler, we use only the best steel. Even the manhole and hand-hole covers are made of pressed steel—not one pound of cast iron being used.

The triple pass through the gases is a feature worth investigating. Write for circular.

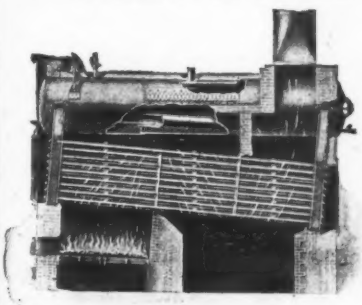
HENRY VOGT MACHINE CO., INC.,
LOUISVILLE, KY.

HEINE WATER TUBE BOILERS
AND SUPERHEATERS
All Flange Steel Construction

Send for { Boiler Logic and / Superheater Logic

Heine Safety Boiler Co. 4210 Olive St., St Louis, Mo.

Water Tube Boilers



All Wrought Steel Construction

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ESTABLISHED 1865.

E. KEELER CO.
Williamsport, Pa.

New York, Philadelphia, Chicago, San Francisco, Wilkesbarre and New Orleans.

Edge Moor Boilers

—WATER TUBE—

EDGE MOOR IRON CO., Edge Moor, Delaware

No Contraction of Area at Drum Connection.

Send for Catalog S.

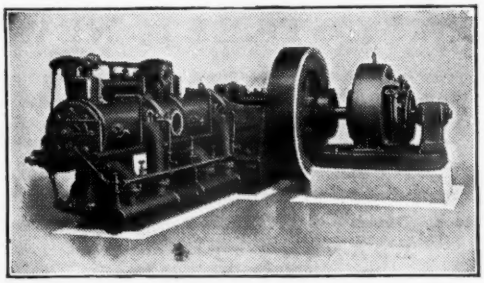
MORRIN **CLIMAX** BOILERS

produce more steam per pound of coal than any other make. This is a strong statement, but we have strong proof to back it. Write for full particulars.

THE MORRIN CLIMAX BOILER COMPANY, - BROOKLYN, N. Y., U. S. A.

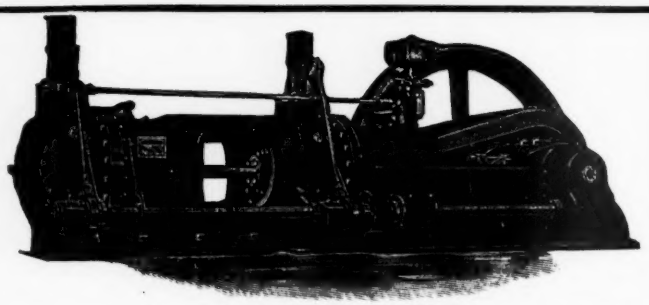
IMPROVED TYPE DU BOIS GAS ENGINES

We guarantee to show highest economy when operating Electric and General Service Types on natural gas, city gas, gasolene or producer gas.



We guarantee these engines to prove cool running, easily governed and free from valve troubles. Catalog "G."

DU BOIS IRON WORKS Established 1877 805 Brady St., Du Bois, Pa.



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AND
SUCTION GAS PRODUCERS

SATISFACTORY AND CONTINUOUS SERVICE
REGULATION AND ECONOMY GUARANTEED

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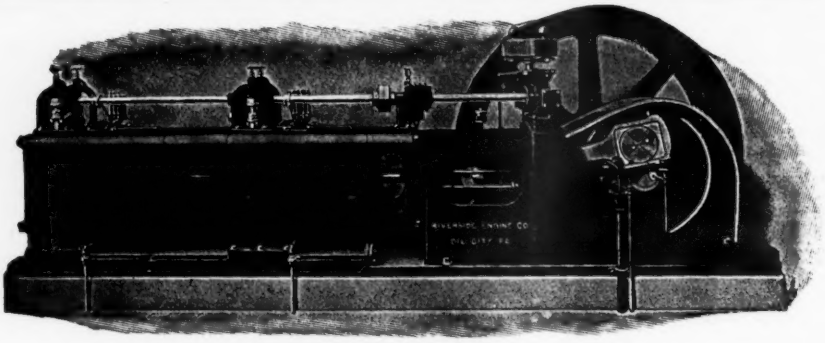
FEW IN NUMBER
EASY OF ACCESS

ENGINES OF VERTICAL AND HORIZONTAL TYPES

75,000 HORSE POWER IN SUCCESSFUL OPERATION

STRUTHERS-WELLS COMPANY, - - - Warren, Penna.



Riverside Heavy Duty Single Acting Tandem Gas Engine (Class C),

Not Made From Wash Drawings

The cuts we show are made from engines we have built and delivered to purchaser, and they are giving steam engine satisfaction at a fraction of the cost, some of them in twenty-four hours' service. The RIVERSIDE heavy duty gas engine, is wholly unlike any other and is built in twelve types and seventy-two sizes from 10 to 2500 H.P.

We also Build a Complete Line of Gas Driven Air and Gas Compressors

Riverside Engine Company, Oil City, Pa.

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20 x 42 Allis, Corliss	16 x 32 Buckeye, Automatic
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Also large assortment of Automatic and Throttling Engines of other sizes.

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84 x 18, 78 x 16, 72 x 18 High Pressure, 72 x 16, 66 x 16 and smaller sizes of Horizontal Tubular Boilers, also Vertical and Fire Box Boilers from 5 to 60 H. P.

Heaters, Pumps, Tanks, Saw Mills, Iron Working Tools, etc., etc.
Write for bargain list.

We are the sole manufacturers of the celebrated "Leader" Injectors and Jet Pumps.

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Lammert & Mann

Engineers and Machinists

157 S. Jefferson Street, CHICAGO

WE MAKE A SPECIALTY OF

Corliss Engine Repairs. Engines Indicated.
General Jobbing. Repairing Engines.
Pumps, etc., all kinds Special Machinery.
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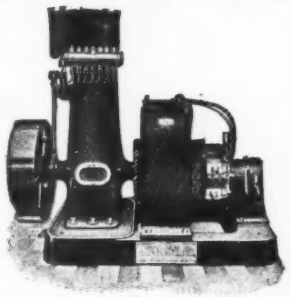
Better Lights at Less Cost

If you have a boiler in your plant this generating set will furnish steady lights more cheaply than you can buy current from public mains. Circular for particulars.



Engberg's Electric and Mechanical Works,
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The New Babbit

The Reeves "C" Bearing Metal does better work and lasts longer than any you have ever used. Ask your dealer for it. It's 25c a pound. If he can't supply you, write us for a 50-pound trial box.

REEVES PULLEY CO., COLUMBUS, IND.

PRODUCER GAS

THE CHEAPEST POWER IN THE WORLD

GAS ENGINES, GAS PRODUCERS
COMPLETE PLANTS INSTALLED

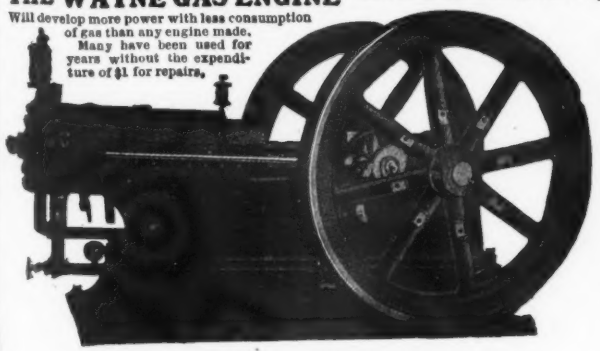
BROOMELL, SCHMIDT & STEACY CO.,
YORK, PENNSYLVANIA.

The overload capacity of **C-W** electric generators makes them popular with the engineer. In emergencies they do better than is expected of them. Bulletin 80M describes our D. C. machines.

CROCKER-WHEELER COMPANY
Ampere, N. J.

THE WAYNE GAS ENGINE Gas Producers from 35 H. P. up.

Will develop more power with less consumption of gas than any engine made. Many have been used for years without the expenditure of $1 for repairs.



Each engine covered by a positive guarantee. Send for Catalog

The Fort Wayne Foundry and Machine Co., Fort Wayne, Ind.
New York Office: 100 BROADWAY.

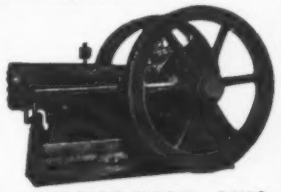
FOOS GAS AND GASOLINE ENGINES

HAVE WIPE SPARK IGNITER, positive acting and self cleaning.

VERTICAL VALVES, mechanically operated, admit fuel charge into cylinder at atmospheric pressure.

CENTER-LINE COUNTERBALANCING increases the efficiency and decreases the fuel bills.

ACCESSIBLE DESIGN makes it a simple matter to keep Foos Engines properly adjusted.



Get Catalog K.

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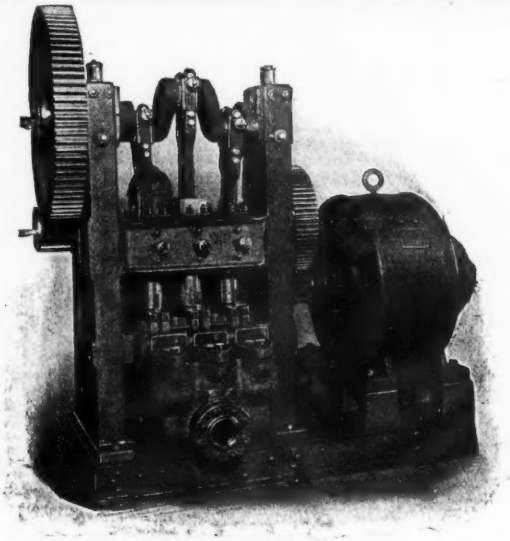
Motors For Pumps

It is no trouble

to place motor-driven pumps exactly where wanted. There are no lines of leaking, power-wasting piping to worry about, just wires. You can run wires anywhere.

Ask nearest office for information.



Westinghouse Motor Driving Gould's Triplex Pump

Westinghouse Electric & Mfg. Co.,

Atlanta Baltimore Boston Buffalo Chicago Cincinnati Cleveland Dallas Denver Detroit Kansas City Los Angeles Minneapolis New Orleans New York Philadelphia Pittsburgh St. Louis Salt Lake City San Francisco Seattle Syracuse

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"True In The Long Run."

"YOUNGER TRIUMPH"

A little duplicate of the regular Triumph compressor. Built to make only from 2 to 3½ tons of ice, it performs its work as economically as our 50 ton compressor. The Younger Triumph is "True In The Long Run."

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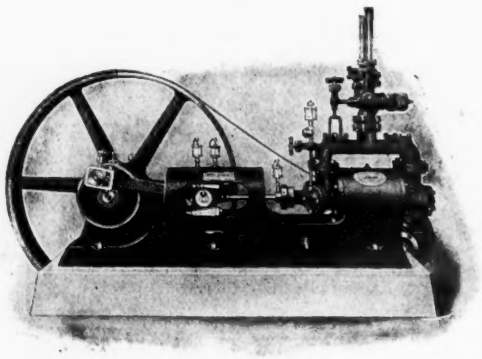

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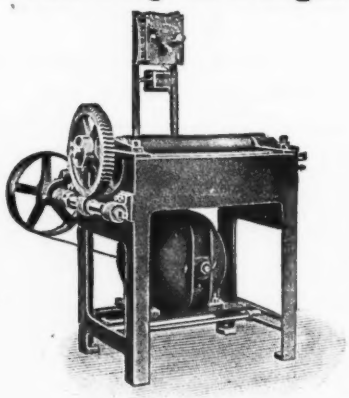
TRIUMPH
MOTORS
For Service

Let us send you our booklet "The Way to Forget"



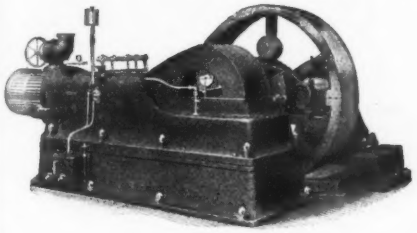
Stereotyper's Cylinder Shaver and Belted Motor.

TRIUMPH ELECTRIC CO.
CINCINNATI, OHIO.

New York, 1 Madison Ave. Chicago, Great Northern Bldg.

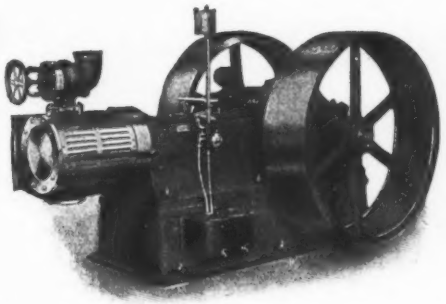
Skinner Engines

CENTER CRANK
SIDE CRANK
SINGLE and FOUR VALVE



SIDE CRANK TYPE

Skinner Engine Co.,
Erie, Pa.



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The Cylinders of
SHEPHERD ENGINES
are cast in one piece, from a special mixture of remelted charcoal iron, as hard as can be machined. Seldom, if ever, need reboring. Catalog?
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Drive Your Power Plant Auxiliaries With Northern Motors

Power plant auxiliaries require trustworthy power. Northern Motors meet this requirement exactly. You can always rely on your pumps, conveyors, blowers, etc., as far as the power is concerned, if driven by Northern Machines.
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U.S. METAL POLISH — Economical — Dependable — G. W. Hoffman, Sole Prop. 295 E. Wash. St. Trade Mark Indianapolis Ind. — INFALLIBLE — FOR POLISHING GOLD, SILVER, PLATED WARE, NICKEL, TIN, BRASS, COPPER, Etc. — DIRECTIONS: Take a little of the Polish on a soft cloth, rub the Metal hard and then wipe it off with a dry cloth. — A Recognized Success — For Cleanliness

THE ONLY METAL POLISH
that works quick and easy and keeps its lustre. Holds old trade and makes new. IT DOES NOT DETERIORATE. Established 16 years.
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Sold by Agents and Dealers all over the world. Ask or write for Free samples. Highest Award, Chicago, '93; St. Louis, '04.
GEO. W. HOFFMAN, Expert Polish Maker,
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Branches—New York, Chicago, San Francisco.

We Manufacture
AN ECONOMICAL AND DURABLE ROTARY ENGINE
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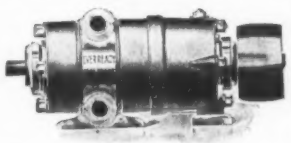

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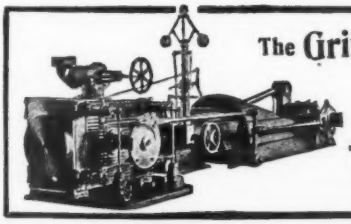
316 HUDSON ST., NEW YORK CITY and 159 GREEN ST., BOSTON.



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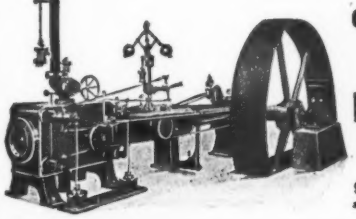
Established 1840
Zanesville, Ohio, U. S. A.
Manufacturers of
The Ohio Corliss Engine and Hoisting Engines



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Refrigerating and Ice Making Machinery
THE VILTER MFG. CO.
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ACCURATE REGULATION FOR ELECTRIC SERVICE—AUTOMATIC CUT-OFF AND RITES FLY-WHEEL GOVERNOR
A.H. ALBERGER COMPANY
45 TO 600 H.P. USING NATURAL GAS
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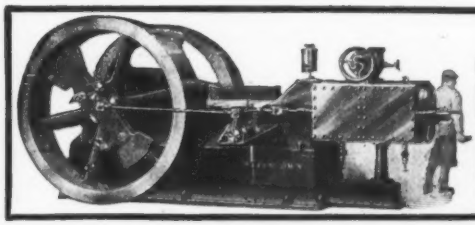
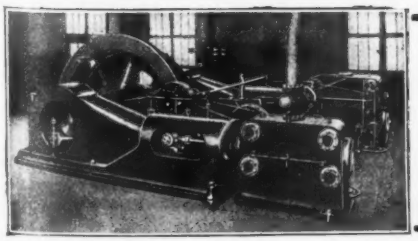
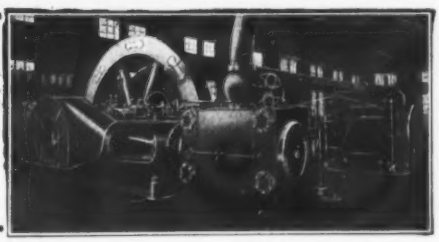
695-697 ELLICOTT SQ. BUFFALO, N.Y.



Good Engines for every power purpose. Ask for Catalog.
Watertown Engine Co., Watertown, N. Y.



RICE & SARGENT CORLISS ENGINES
Speeds Higher than other Corliss types. For direct connection to Generators in sizes from 100 K.W. to 7500 K.W., also belt and rope drive or direct connected to a line shaft.
Designed and Built by
Providence Engineering Works,
Main Office and Works, PROVIDENCE, R. I.



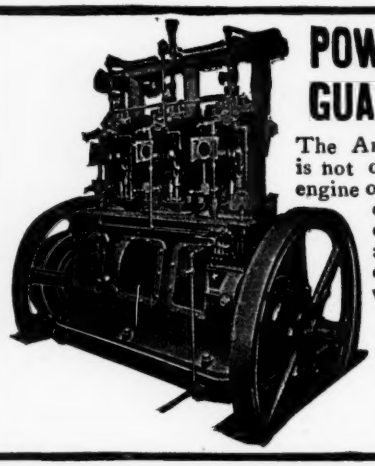
SOUTHWARK FOUNDRY AND MACHINE CO.

PHILADELPHIA, PA.

Our type of BLOWING ENGINES for Blast Furnaces and Bessemer Steel Works is largely used in the United States and Europe.

Built of vertical and horizontal pattern; simple and compound steam ends; and air cylinders fitted with our patented grid-iron valves which make it possible to operate at higher speeds than with the usual form of air valve.

CATALOG UPON APPLICATION.



POWER COSTS GUARANTEED

The American Diesel Engine is not only the most efficient engine on earth but it burns the cheapest liquid fuel—crude oil. We can guarantee a cost which no other engine can develop under test.

Write for Catalogue.

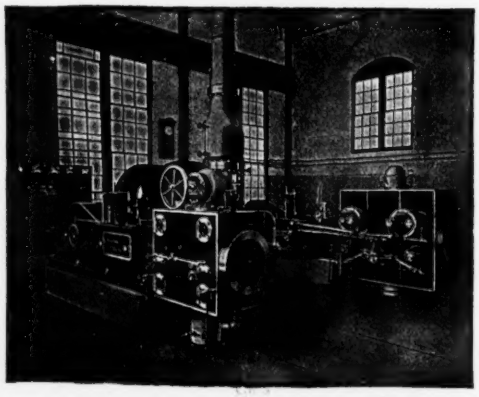
AMERICAN DIESEL ENGINE CO.
11 Broadway, N. Y.

"BALLWOOD" Engines

may cost a little more than the ordinary kind, but their higher and more permanent efficiency and economy make them far superior to any other. They save and satisfy.

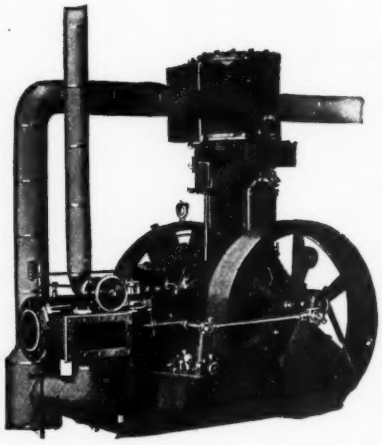
CATALOG ?

THE BALL & WOOD CO.,
ELIZABETHPORT, N. J.
New York Sales Office, Cortlandt Building, 30 Church Street.
MAKERS OF BALLWOOD FLANGES.



The Ball Engine Co.,
Erie, Pa.

The Engine For Upper Floors



A single piston engine cannot be exactly balanced. If no counter balance weights are put on, powerful forces due to the rapid starting and stopping of the piston, piston rod and connecting rod tend to push the engine frame to and fro.

If a counterbalance just heavy enough to neutralize these forces is put on, equal unbalanced forces are created in a direction at right angles. The engine tends to hop up and down on its foundations.

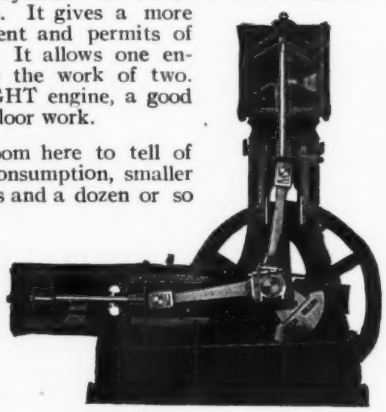
Neither the horizontal nor the vertical forces of an engine running at high speed are good for the concrete-steel second story floor nor for a steel frame or brick or stone building. They tend to loosen joints and to shake the building down, to say nothing of racking nerves.

How then is such vibration to be avoided? By installing an

American-Ball Angle-Compound Engine

in which the unbalanced forces of two pistons set at right angles are combined so that their resultant can be balanced perfectly in all positions by one counterweight. This balancing saves not only the joints of the building, but also the joints of the engine, since it is only through the bearings that unbalanced forces can be transmitted from moving parts to the engine frame and foundations. The angle-compound therefore, not only runs smoother, but lasts longer.

Putting two cylinders at work on one crank has another advantage. It gives a more even turning moment and permits of a lighter flywheel. It allows one engine frame to do the work of two. The result is a LIGHT engine, a good quality in second floor work.



We haven't room here to tell of the lower steam consumption, smaller space requirements and a dozen or so other advantages possessed only by the American-Ball Angle-Compound Engine, but you will find them concisely described in our 32-page book which we would be glad to send upon request. 10

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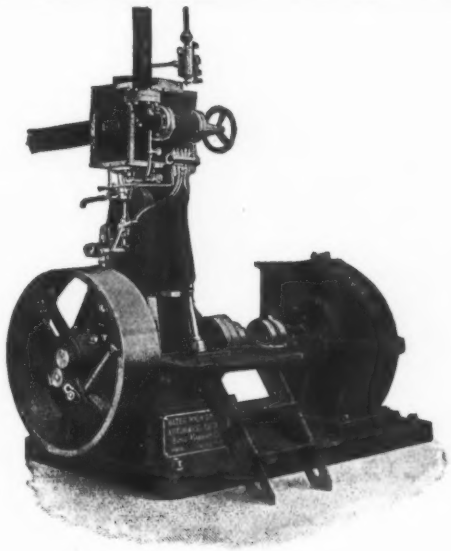

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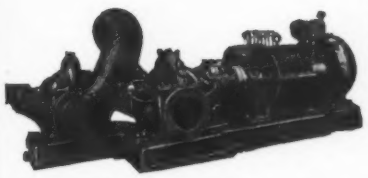

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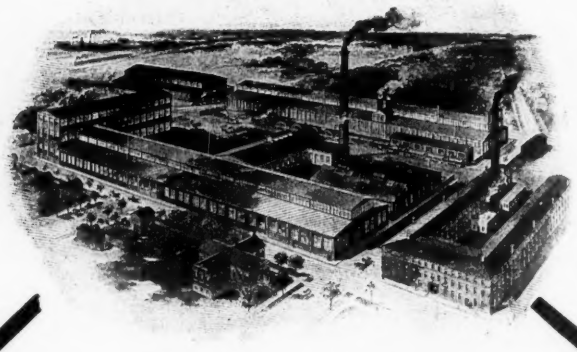

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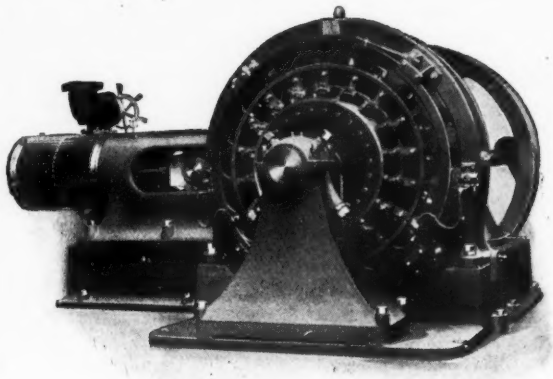

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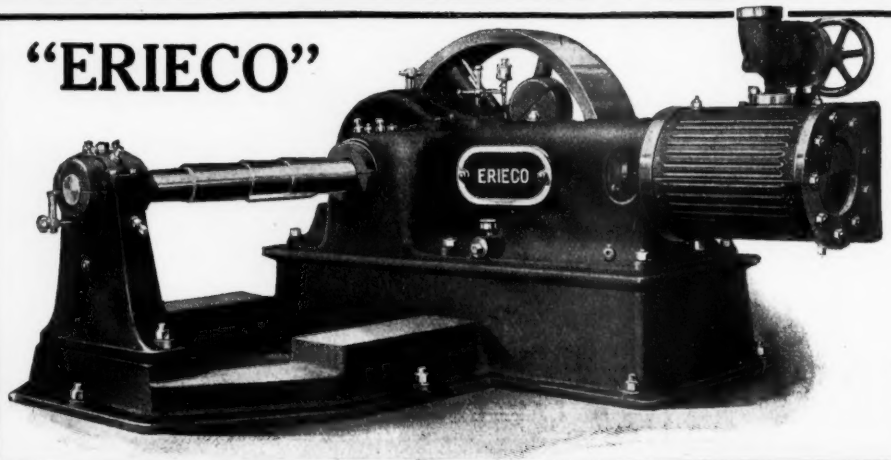

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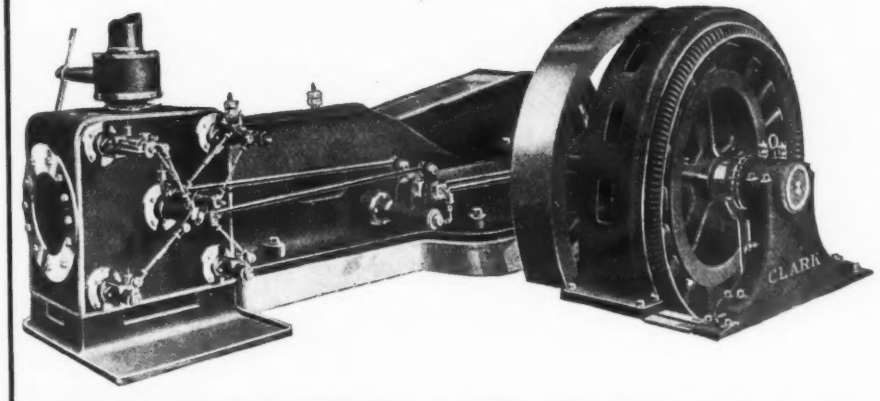

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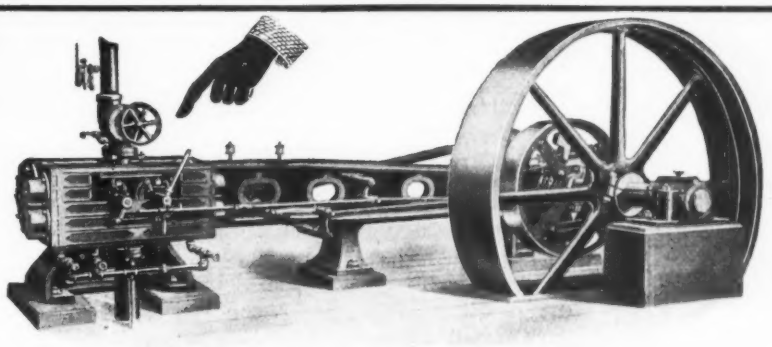

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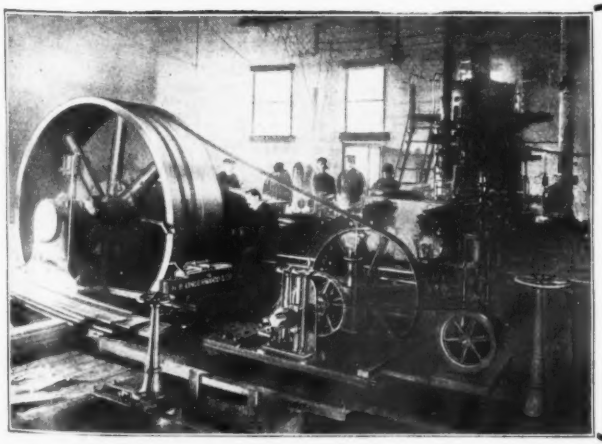

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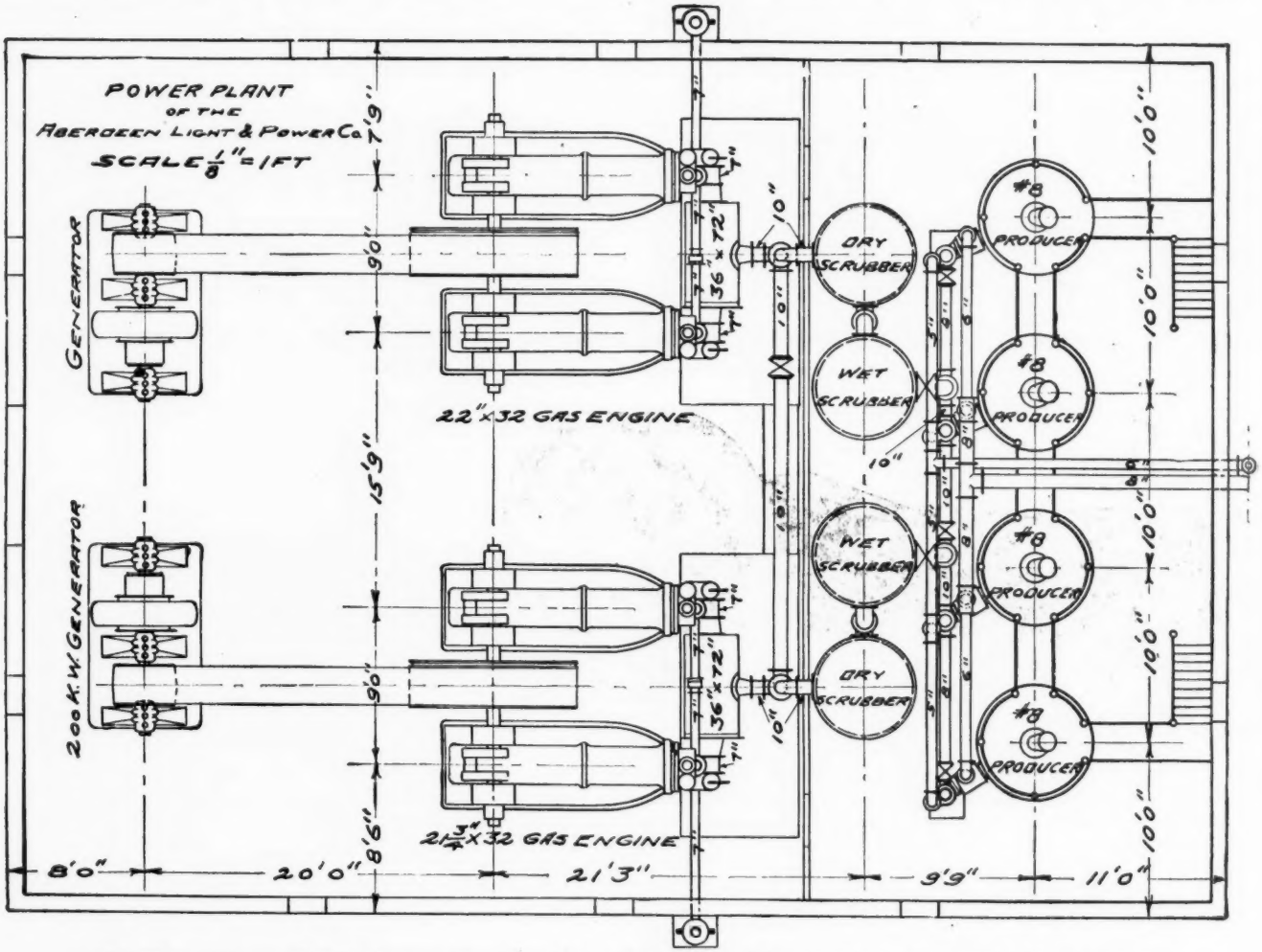

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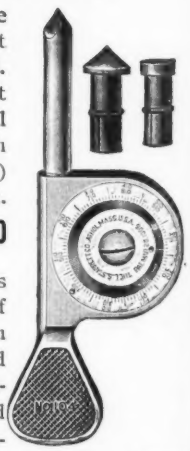

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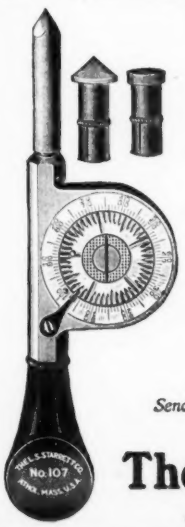

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